NASA CR-166738

COMPUTER TECHNOLOGY ASSOCIATES INC

INTEGRATED COMMAND, CONTROL COMMUNICATION AND COMPUTATION SYSTEM STUDY

FINAL REPORT

NAS5-26239

COMPUTER TECHNOLOGY ASSOCIATES, INC.

August 1981

FOREWORD

This Integrated Command, Control, Communications and Computation (IC^4) System Study Final Report has been prepared by Computer Technology Associates, Inc., Denver, Colorado as a data requirement in the performance of the IC^4 study contract NAS5-26369 for NASA Goddard Space Flight Center.

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this document is to summarize the results of the Integrated Command, Control, Communications and Computation (IC^4) system study (contract NAS5-26369).

1.2 Scope

The IC^4 system study was awarded to Computer Technology Associates, Inc. in September, 1980. This study was conducted in the following three phases:

a. functional requirements phase
b. functional architecture phase
c. design plan phase.

The results of the functional requirements phase were documented in Reference 2. The results of the functional architecture phase were documented in Reference 3. The results of the design plan phase were documented in the July 31, 1981 monthly status report (Reference 1). This report provides a synopsis of the activities and results of the three study phases.

1.3 Acronyms and Abbreviations

CG&V	Command Generation and Validation
CRT	Cathode Ray Tube
D/L	Downlink
GSTDN	Goddard Space Tracking Data Network
H&S	Health and Safety
IC^4	Integrated Command, Control, Communication, and Computation
IOS	Integrated Observatory Sequence

LRP	Long Range Planning
NEEDS	NASA End-to-End Data System
OBC	On-Board Computer
P&S	Planning and Scheduling
POI	Period of Interest
R/T	Real-Time
TDRSS	Tracking and Data Relay Satellite System
TM	Telemetry
U/L	Uplink

2.0 APPLICABLE DOCUMENTS

1. IC^4 System Study Contract Monthly Reports
2. IC^4 System Functional Requirements, Computer Technology Associates, Inc., March 31, 1981.
3. IC^4 System Functional Architecture, Computer Technology Associates, Inc., August 1981.

3.0 FUNCTIONAL REQUIREMENTS PHASE

The purpose of this section is to describe the functional requirements phase of the IC^4 study. The results of the requirements study are documented in the IC^4 System Functional Requirements document (Reference 2).

3.1 Functional Requirements Approach

As shown in Figure 3.1-1 the generation of the requirements for the IC^4 system first consisted of performing a survey of applicable documents and missions to determine a comprehensive set of command and control requirements. The requirements were then divided into natural groupings such that they could be analyzed from a top level perspective. (The outline given in section 3.4 of reference 2 lists the requirements in the groups shown in Figure 3.1-1). The requirements were then analyzed by building a framework system around the groupings which allowed interrelationships to be studied. Figure 3.1-2 summarizes the activities undertaken during this stage of the requirements analysis.

3.2 Functional Requirements Results

As shown in Figure 3.1-3 the results of the requirements gathering and analysis resulted in a complete set of functional requirements. It should be noted that these were generic requirements for a broad range of missions and were not specific to any mission; thus, mission unique items such as time of response or data volumes to be handled were not specified. Figure 3.1-4 illustrates the overview of the groupings studied during the requirements analysis. (Note: This overview was modified during the architecture study as shown in Figure 4.2-1.)

Figure 3.1-1

IC^4 FUNCTIONAL REQUIREMENTS - APPROACH

- ANALYZE EXISTING AND POTENTIAL MISSIONS AND PROGRAMS
  - STUDY SMM, SME, UARS, ERBE, VIKING AND SPACE TELESCOPE
  - REVIEW NEEDS DOCUMENTATION
  - REVIEW OTHER PERTINENT DOCUMENTATION (E.G., SHUTTLE REQ'S)

- COMPILE COMPREHENSIVE LIST OF ALL COMMAND AND CONTROL REQUIREMENTS

- GROUP REQUIREMENTS BY FUNCTION (SOME REQUIREMENTS ARE IN MULTIPLE FUNCTIONS AT THIS POINT)
  - ON-BOARD
  - GROUND-SPACE LINK
  - GROUND DATA TRANSFER
  - SCIENCE EXPERIMENTERS
  - INSTRUMENT AND SUBSYSTEM CONTROL
  - MISSION CONTROL (MISSION MANAGEMENT)
  - FLIGHT ANALYSIS AND MONITOR (ATTITUDE AND ORBIT)
  - SPACECRAFT MONITOR, STATUS AND SUPPORT

Figure 3.1-2

IC^4 FUNCTIONAL REQUIREMENTS – APPROACH (CONTINUED)

- GIVEN REQUIREMENTS AS SUBSETS OF FUNCTIONS, GENERATE A FRAMEWORK SYSTEM TO EXAMINE INTERRELATIONSHIPS

- EXAMINE OPERATIONAL ACTIVITIES AND NECESSARY INFORMATION FLOW

- EXAMINE INTERFACES BETWEEN FUNCTIONS AND INTERFACES CAUSED BY IMPLEMENTATION OF REQUIREMENTS

- DESCRIBE "TEAMS" WHICH CARRY OUT MISSION ACTIVITES AND DEFINE RESPONSIBILITIES

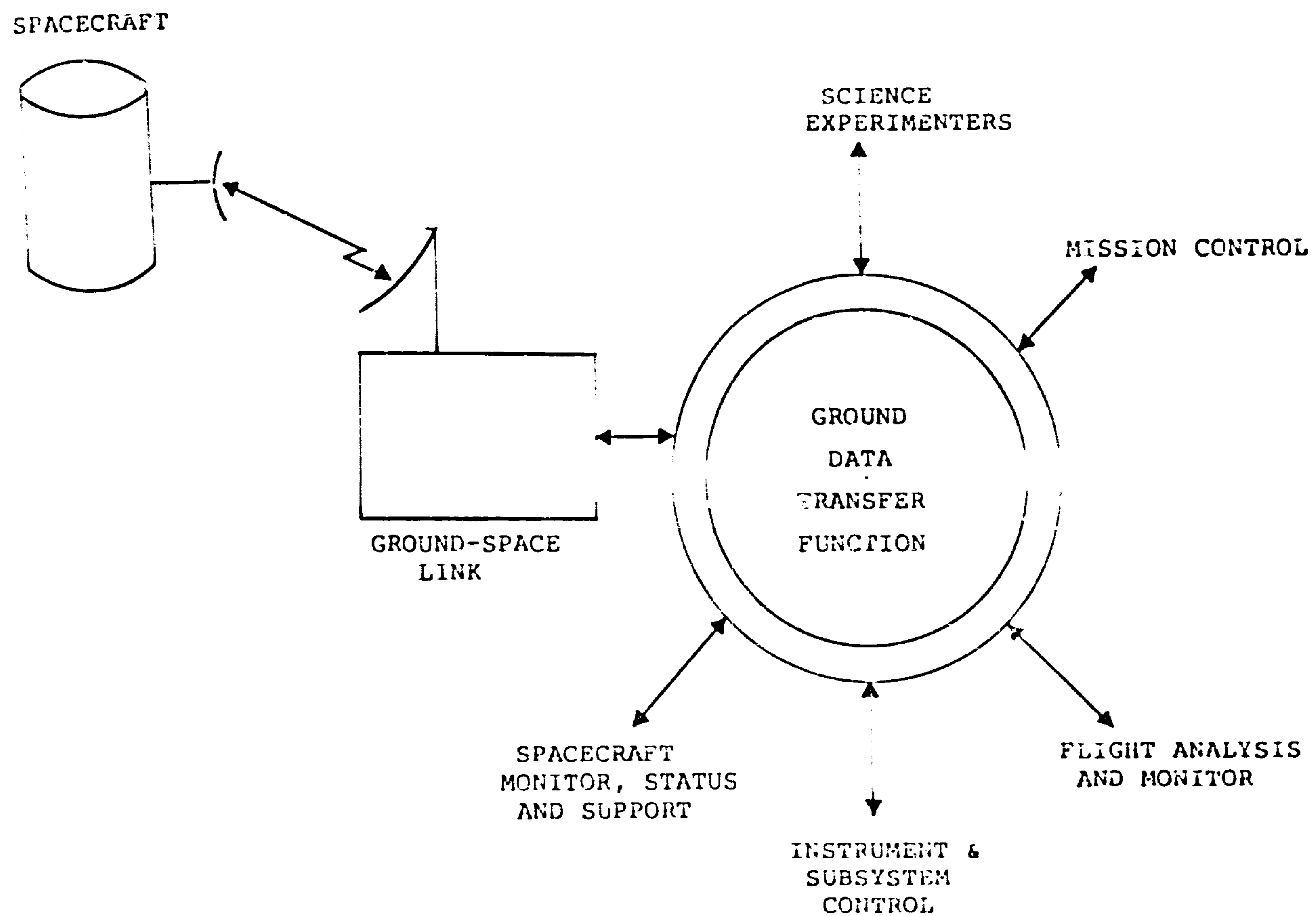
Figure 3.1-3

IC^4 FUNCTIONAL REQUIREMENTS - RESULTS SUMMARY

- DEVELOPED REQUIREMENTS STATEMENT
  - INCLUDES ALL REQUIREMENTS DISCOVERED
  - FUNCTIONS
  - INTERFACES
  - OPERATIONAL ACTIVITIES
  - GROUPED INTO SUBSETS (BUT NOT MUTUALLY EXCLUSIVE SETS)
  - SPECIFIC MEASURABLE REQUIREMENTS (TIMING, OPERATIONAL CYCLE) NOT INCLUDED AS EFFORT WAS TO BUILD COMPREHENSIVE SET, NOT MISSION UNIQUE
- DOCUMENTED IN <u>IC^4 FUNCTIONAL REQUIREMENTS</u>, CTA, MARCH 1981

Figure 3.1-4

IC⁴ FUNCTIONAL REQUIREMENTS - CONCLUDED



4.0 FUNCTIONAL ARCHITECTURE PHASE

The purpose of this section is to provide a synopsis of the functional architecture phase of the IC^4 system study. A description of the approach used to define the functional architecture is provided below. The results, as documented in Reference 3, are summarized in subsequent sections.

4.1 Approach

To define the IC^4 functional architecture, the following three products were generated:

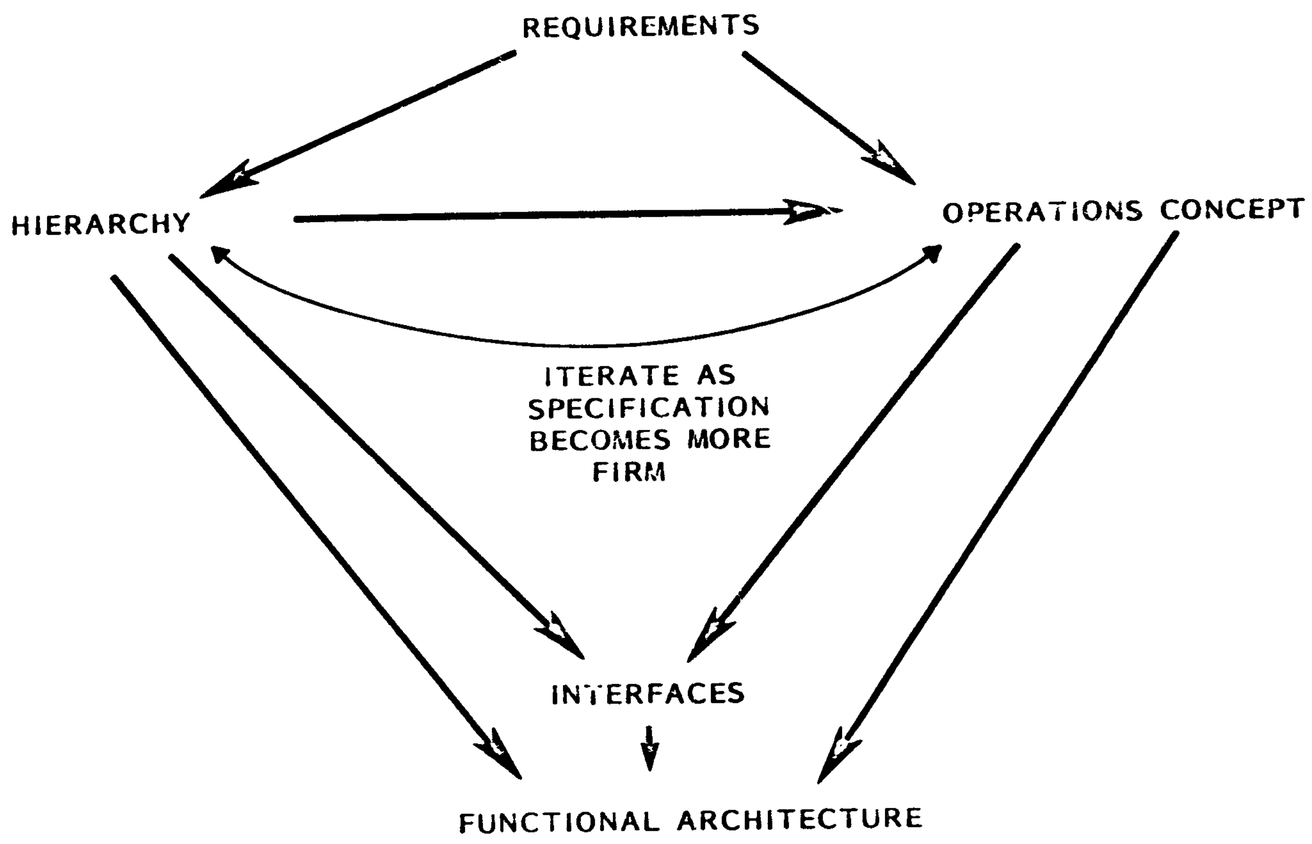
a. functional hierarchy with allocation of functions to IC^4 system elements
b. operations concept with timelines of operational activities
c. interfaces between the system elements.

Figure 4.1-1 summarizes the overall approach to generation of the IC^4 functional architecture. Requirements from Phase 1 provided the basic inputs to this activity. The functional hierarchy and operations concept were derived based on these requirements. However, this process was iterative as the definition of operational activities and allocation of functions levied new requirements on the system. Once the functional hierarchy and operations concept were firm, system interfaces were defined. The result was then the functional architecture. This approach is defined in greater detail below.

4.1.1 Functional Hierarchy

The IC^4 system was divided into the system elements illustrated

Figure 4.1-1
GENERATION OF IC^4 FUNCTIONAL ARCHITECTURE



by Figure 4.1-2. Each element was then decomposed into subsequent functions as shown in Figure 4.1-3. These functions included mission support, element control, data acquisition and utilization and ground control. Each system element performed various combinations of these functions as summarized in section 4.2.2 of this document.

4.1.2 Operations Concept

To define the IC^4 operations concept, four operational activity threads were generated. Figure 4.1-4 summarizes the threads that were developed. These activity threads are defined in detail in section 4.2.4 of this document.

4.1.3 Interfaces

Figure 4.1-5 summarizes the technique used to define the IC^4 system interfaces. The N^2 chart was employed which defines information generated by one element and used by another element. For example, in Figure 4.1-5 the number 6A indicates that the science experimenter generates data that is utilized by mission management. Likewise, the number 6B implies that mission management provides information for the science experimenter element. The interfaces are defined in detail in section 4.2.5 to this document.

4.2 Results

The IC^4 functional architecture is defined in detail in Reference 3. A synopsis of this document is given below.

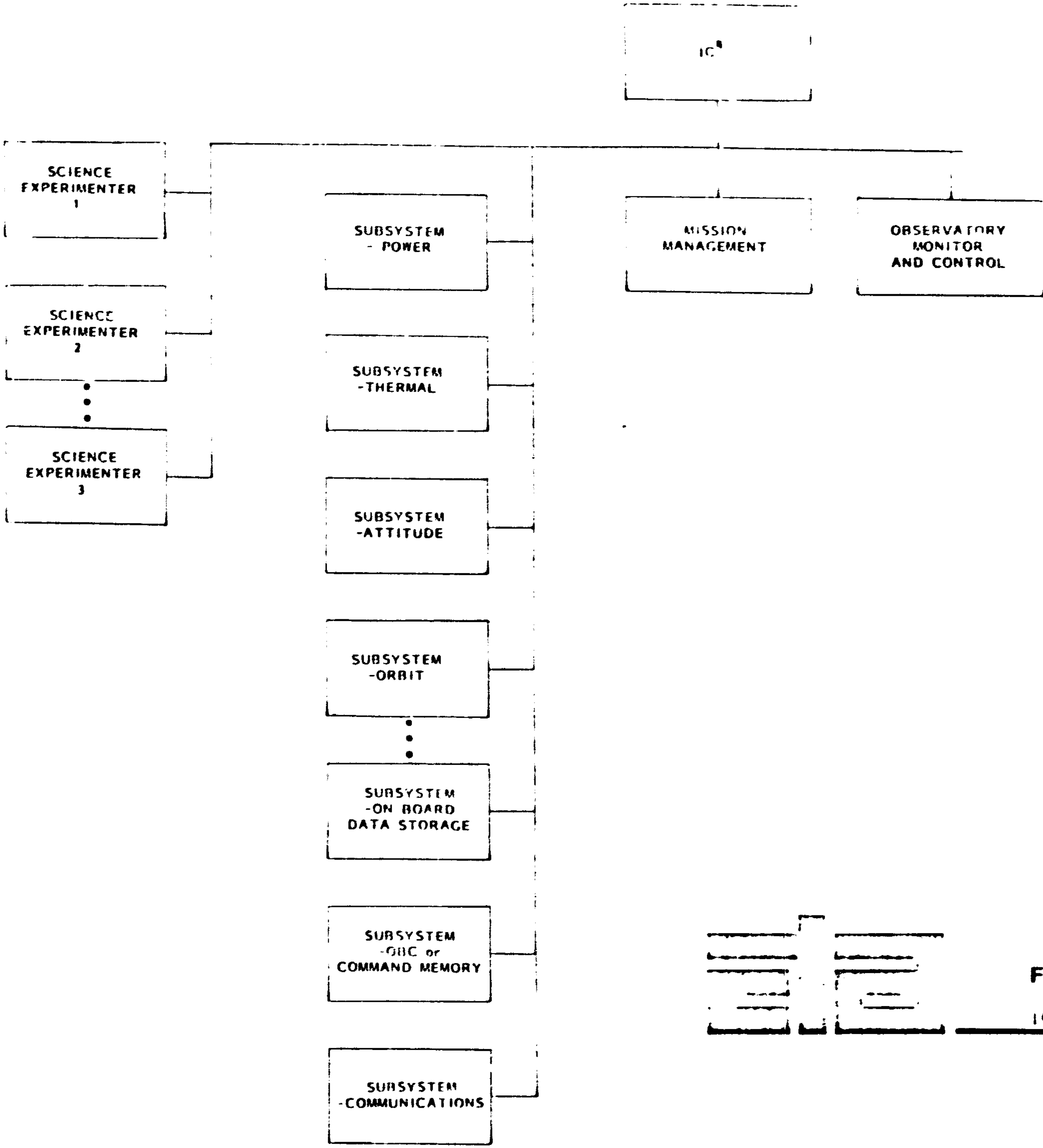


Figure 4.1-2

IC⁴ FUNCTIONAL HIERARCHY

Figure 4.1-3

SYSTEM ELEMENT DECOMPOSITION

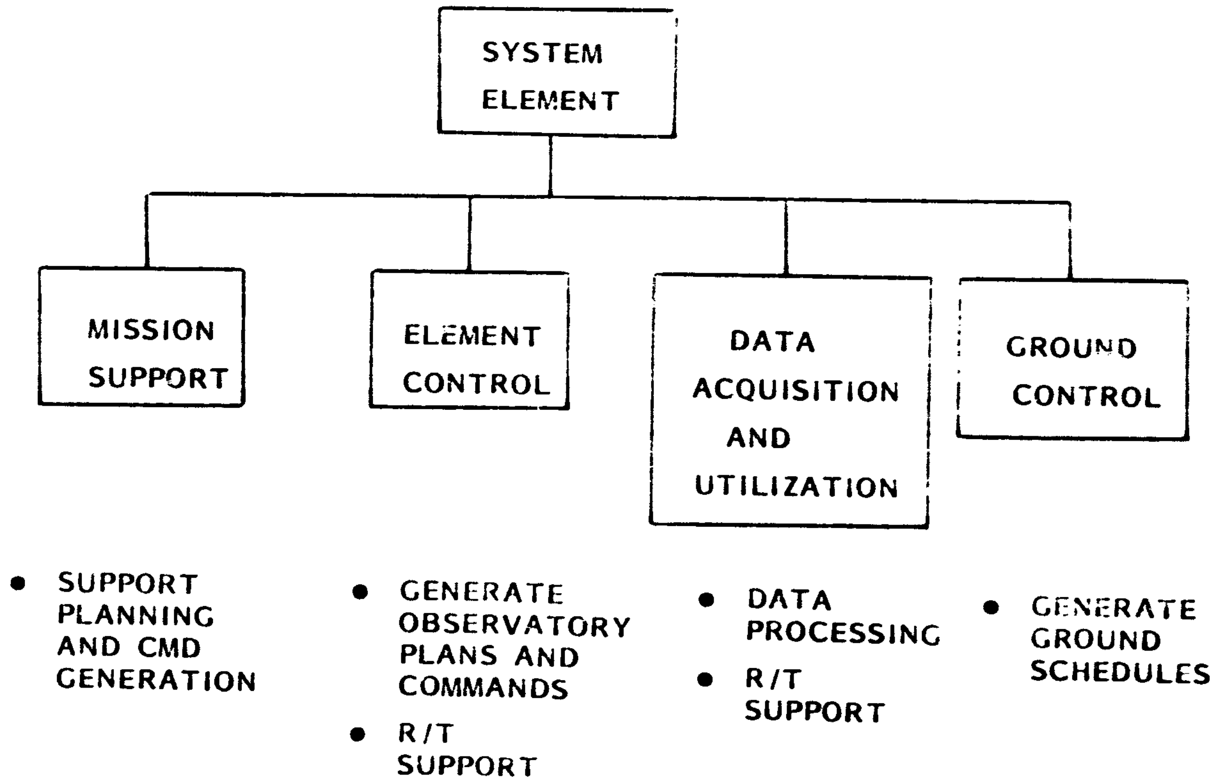


Figure 4.1-4
OPERATIONAL ACTIVITY THREADS

LONG RANGE PLANNING

- ESTABLISH MISSION SCIENCE GOALS AND OBJECTIVES

PLANNING AND SCHEDULING

- GENERATE OBSERVATORY SEQUENCES FOR SELECTED TIME PERIOD

COMMAND GENERATION AND VALIDATION

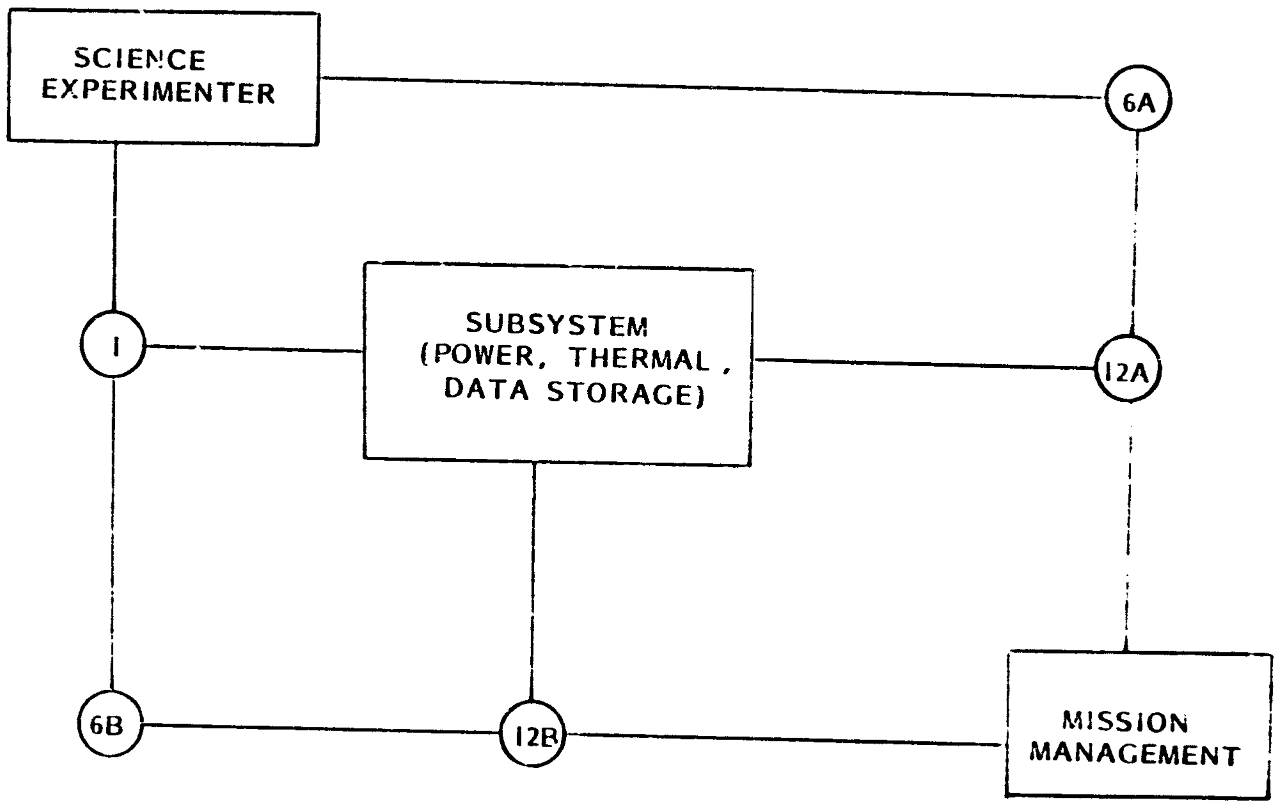
- VALIDATE SEQUENCE FOR S/C SUBSYSTEMS
- GENERATE COMMAND LOADS

REAL-TIME OPERATIONS

- TRANSMIT COMMAND LOADS
- MONITOR DATA
- USER INTERACTIONS

Figure 4.1-5

N² TECHNIQUE TO DEFINE INTERFACES



The following summary information to the functional architecture is provided:

a. overview
b. functional hierarchy
c. key features
d. activity threads
e. interfaces.

4.2.1 Overview

Figure 4.2-1 provides an overview of the IC^4 system. The components or system elements are indicated on the figure. The elements are summarized in section 4.2.2 to this document. Figure 4.2-2 summarizes the IC^4 operational activities. These activities are divided into four phases: a) long-range planning, b) planning and scheduling for a period of interest, c) command generation and validation and d) real-time operations. These activities are summarized in section 4.2.4 to this document.

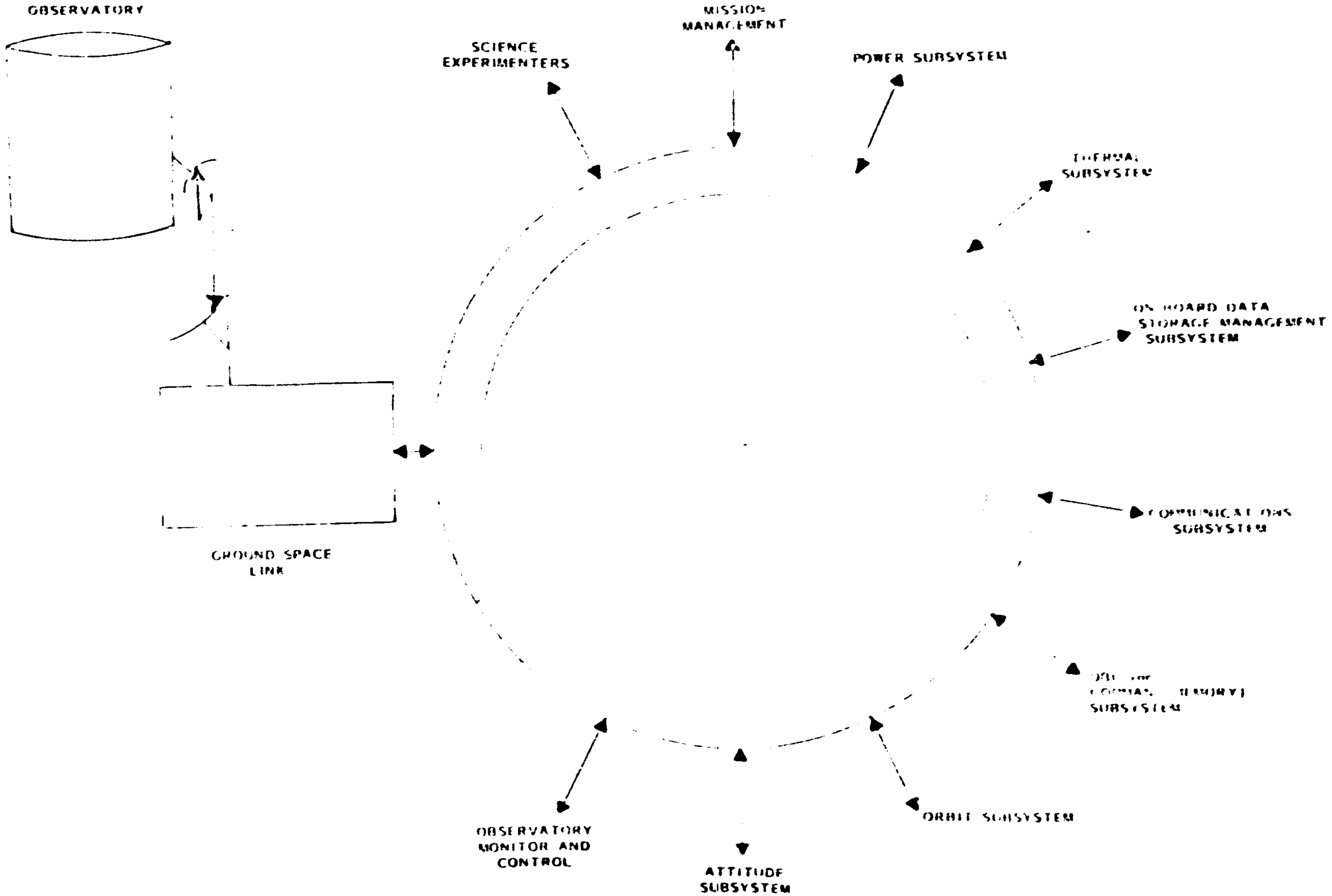
4.2.2 Function Hierarchy

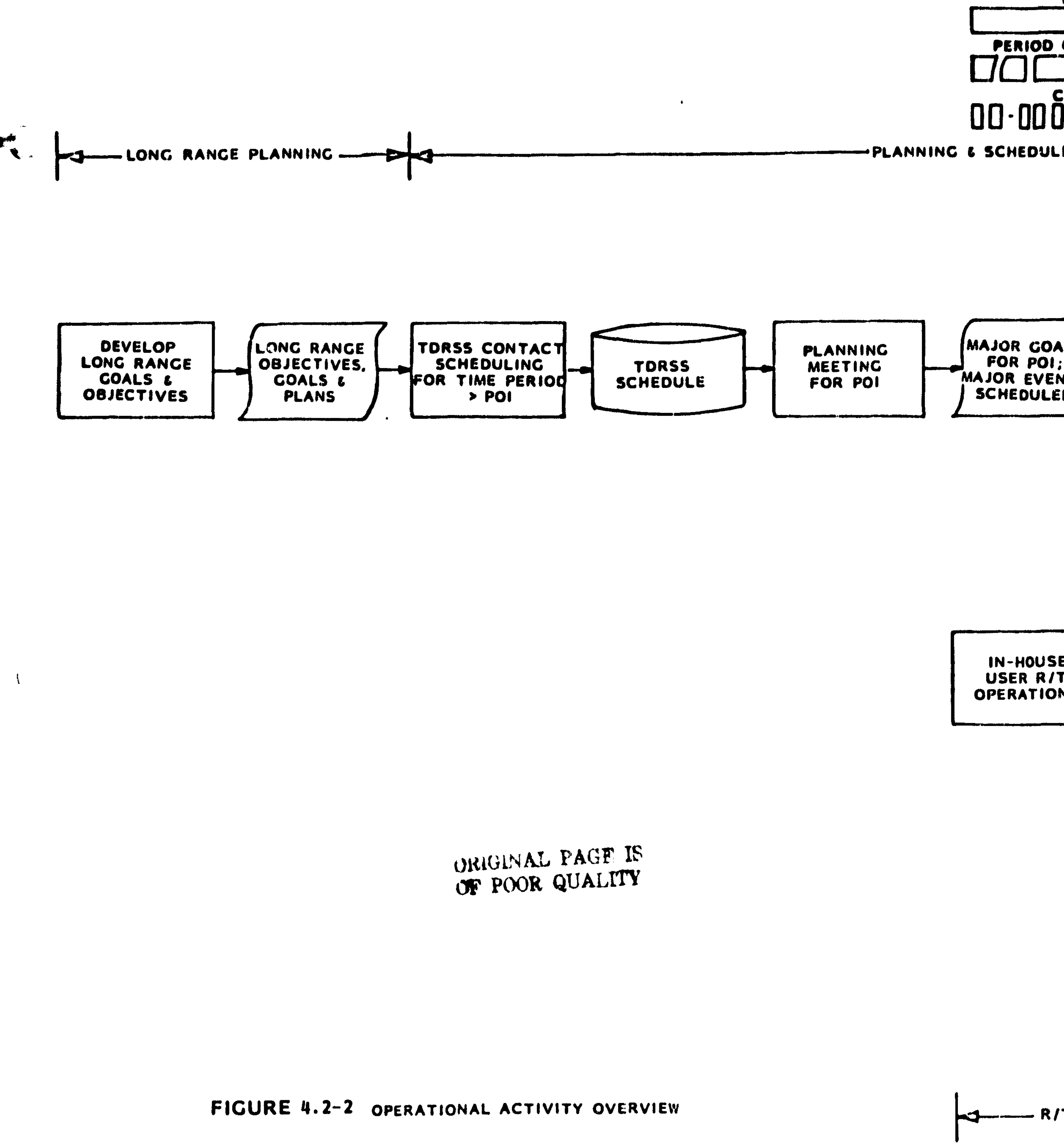
Functional hierarchy charts are provided for the following system elements:

a. science experimenter
b. subsystem (power, thermal, data storage management)
c. OBC (or command memory)
d. subsystem (communications)
e. attitude subsystem
f. orbit subsystem
g. mission management
h. observatory monitor and control.

Figure 4.2-1

FUNCTIONAL ARCHITECTURE - SYSTEM OVERVIEW





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OF POOR QUALITY

FIGURE 4.2-2 OPERATIONAL ACTIVITY OVERVIEW

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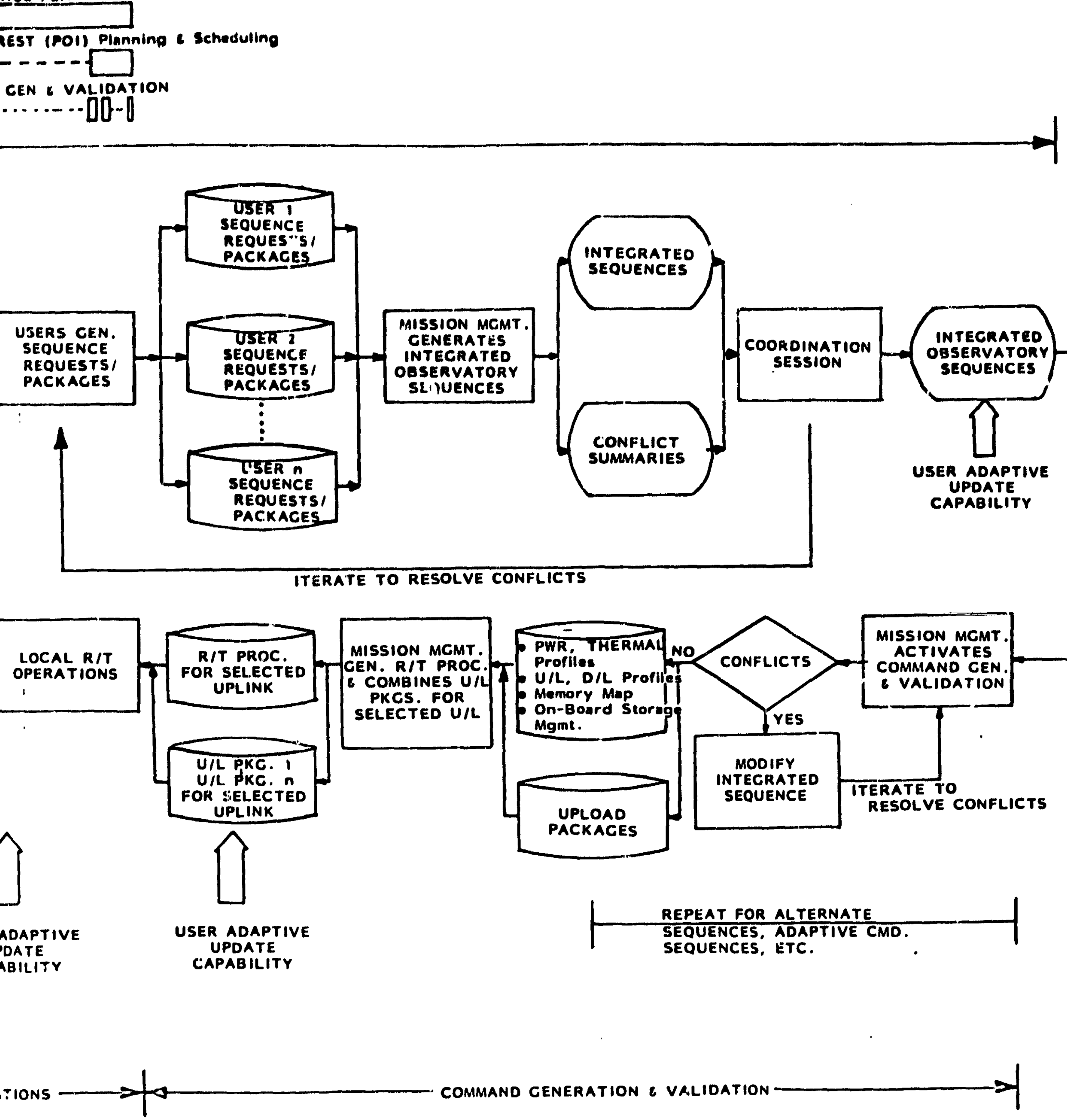

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These charts are contained in Figures 4.2-3 through 4.2-10, respectively. It should be noted that for the purpose of simplification, several of the system elements have been combined as one. The functions of these elements are similar and can be so treated. Each of the elements are subdivided as outlined in section 4.1.1 and functions allocated accordingly. For a detailed description of the IC^4 functional hierarchy refer to Reference 3.

4.2.3 Key Features

Four features are key to the IC^4 system. These key features are as follows:

a. interactive user
b. sequence package
c. adaptive update capability
d. user in-house real-time operations capabilities.

These features are summarized below.

4.2.3.1 Interactive User

The IC^4 system is designed to provide a common means for all users to access data within the system and to utilize facilities provided by the system. This common interface with the system is an interactive graphic terminal. As shown in Figure 4.2-11, the user terminal provides a means to interact with all phases of mission activities. Standard display formats are used which provide the mechanism for users to display data and enter data. The system provides skeletons or templates which provide starting points for data entry and a common framework within which all similar data

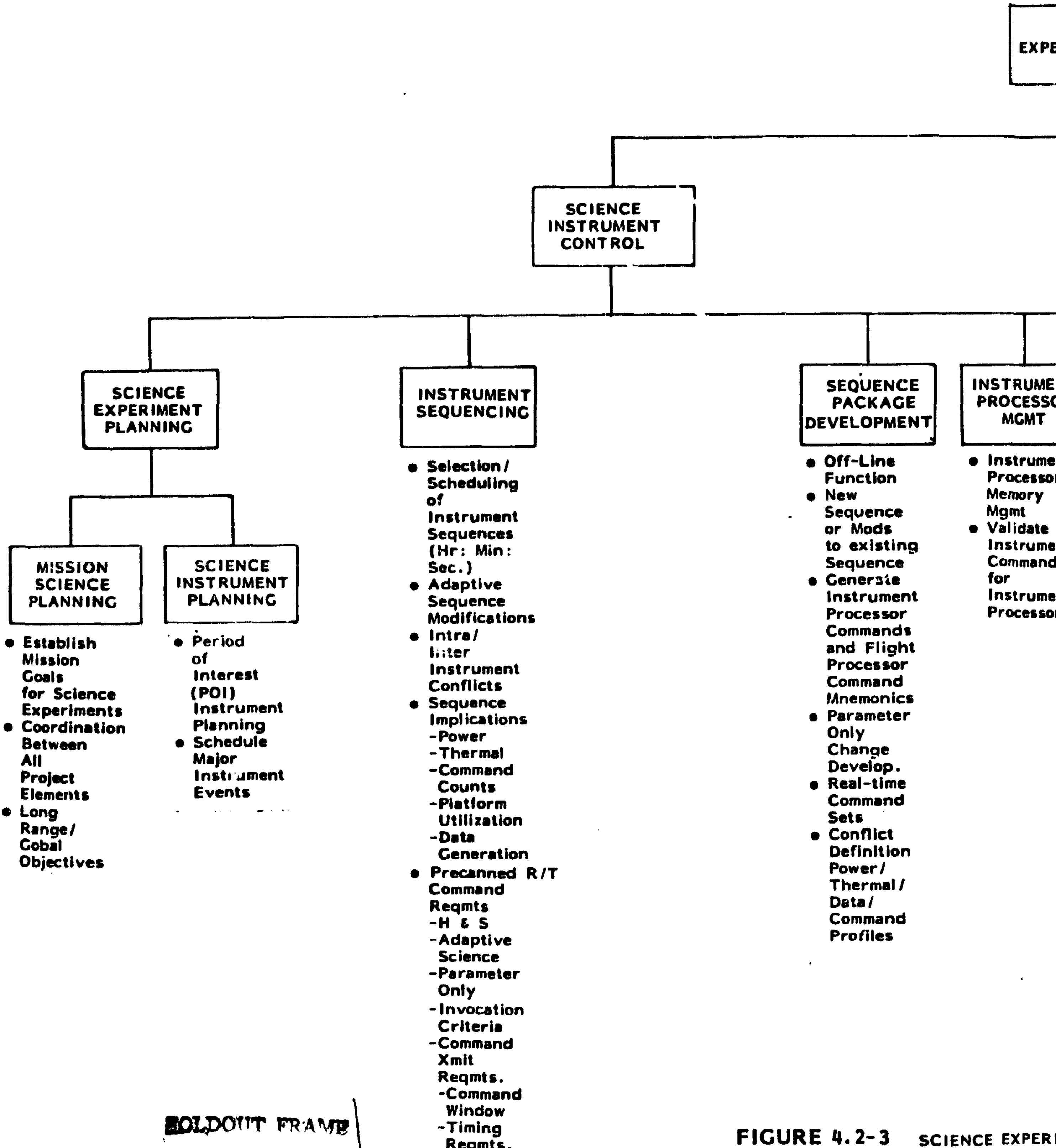
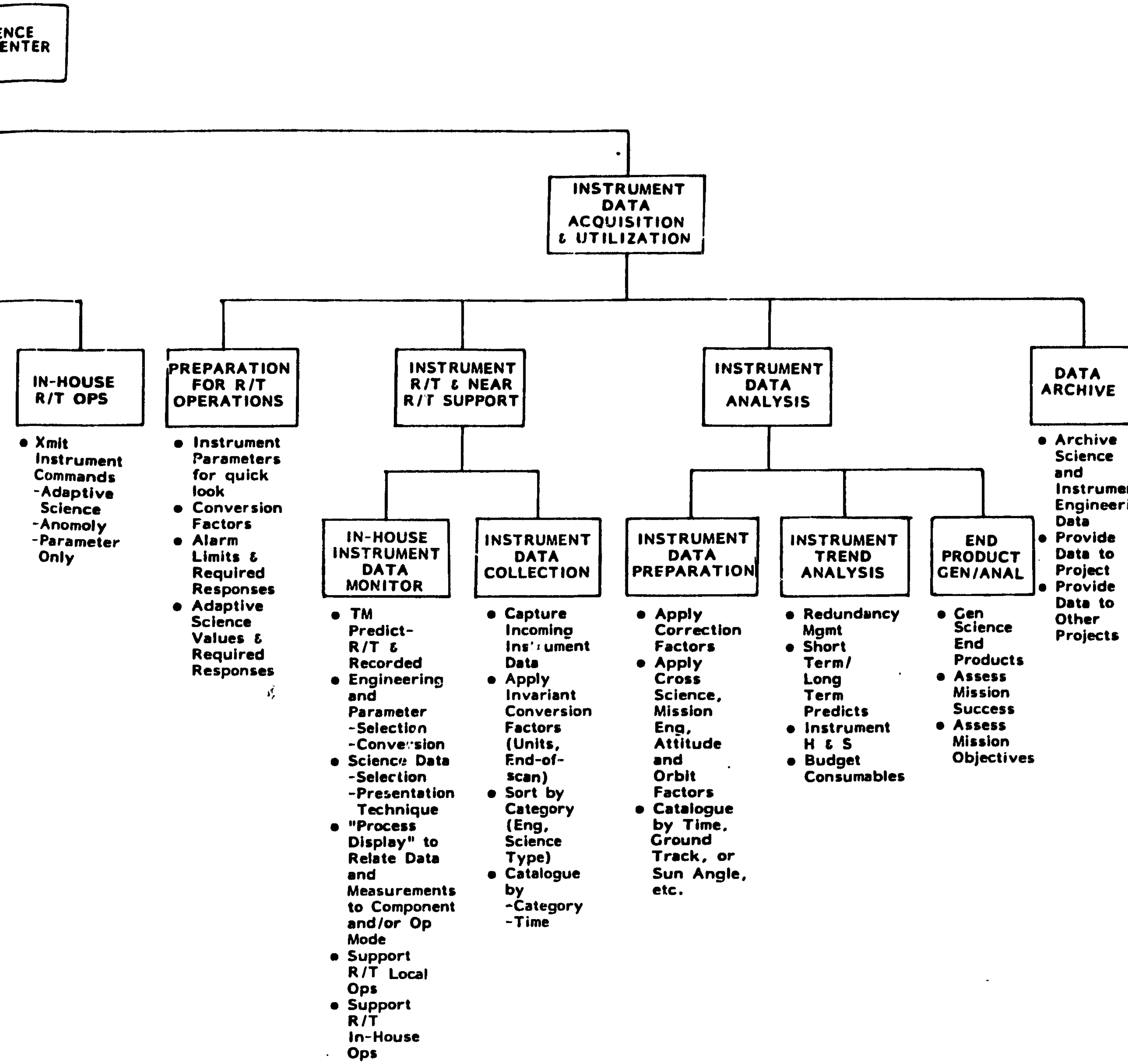


FIGURE 4.2-3 SCIENCE EXPER



TER FUNCTIONAL HIERARCHY

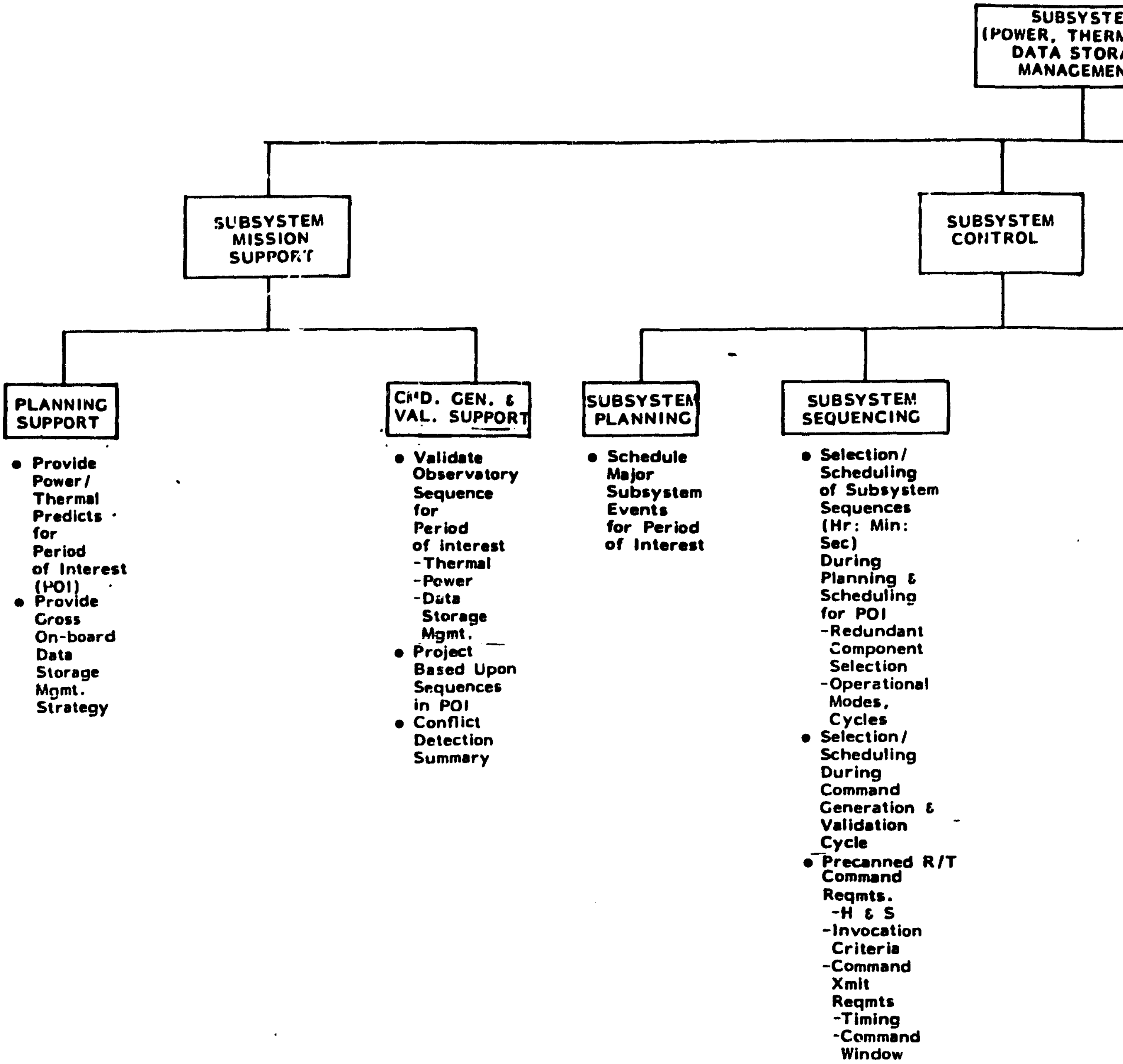
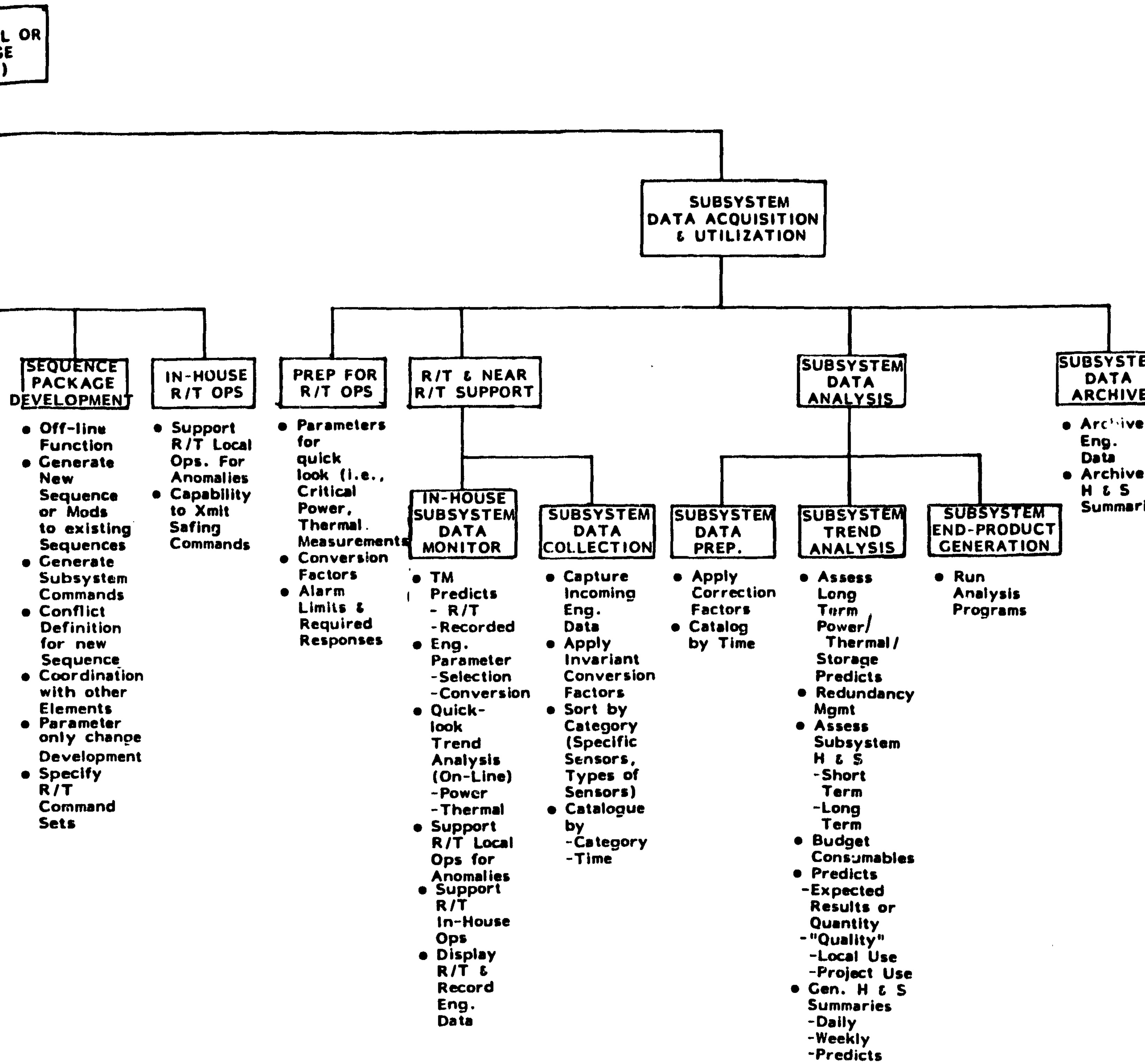


FIGURE 4.2-4 SUBSYSTEM (POWER, THERMAL, OR DATA STORAGE



ANAGEMENT) FUNCTIONAL HIERARCHY

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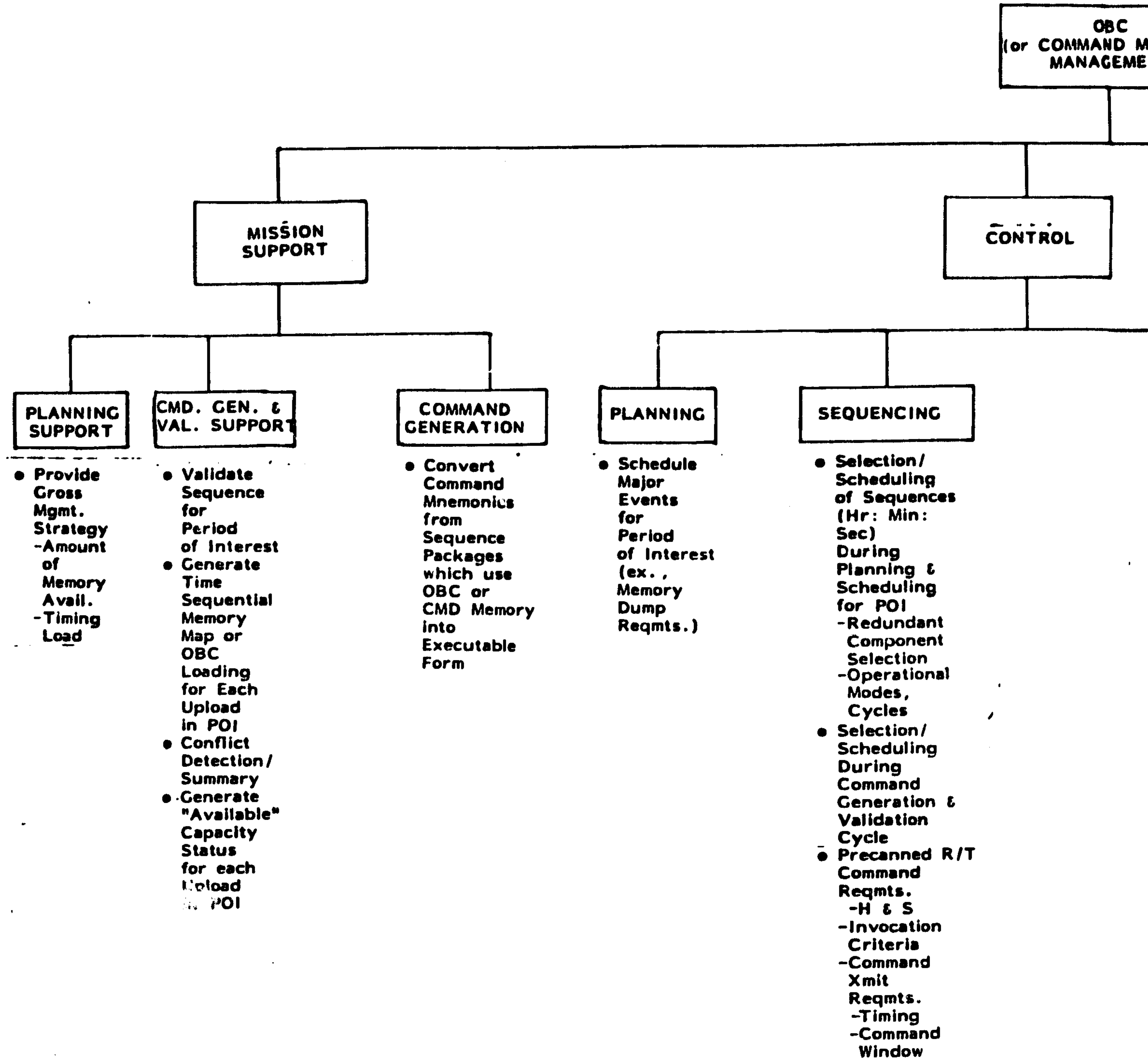

FIGURE 4.2-5 OBC (or COMMAND ME

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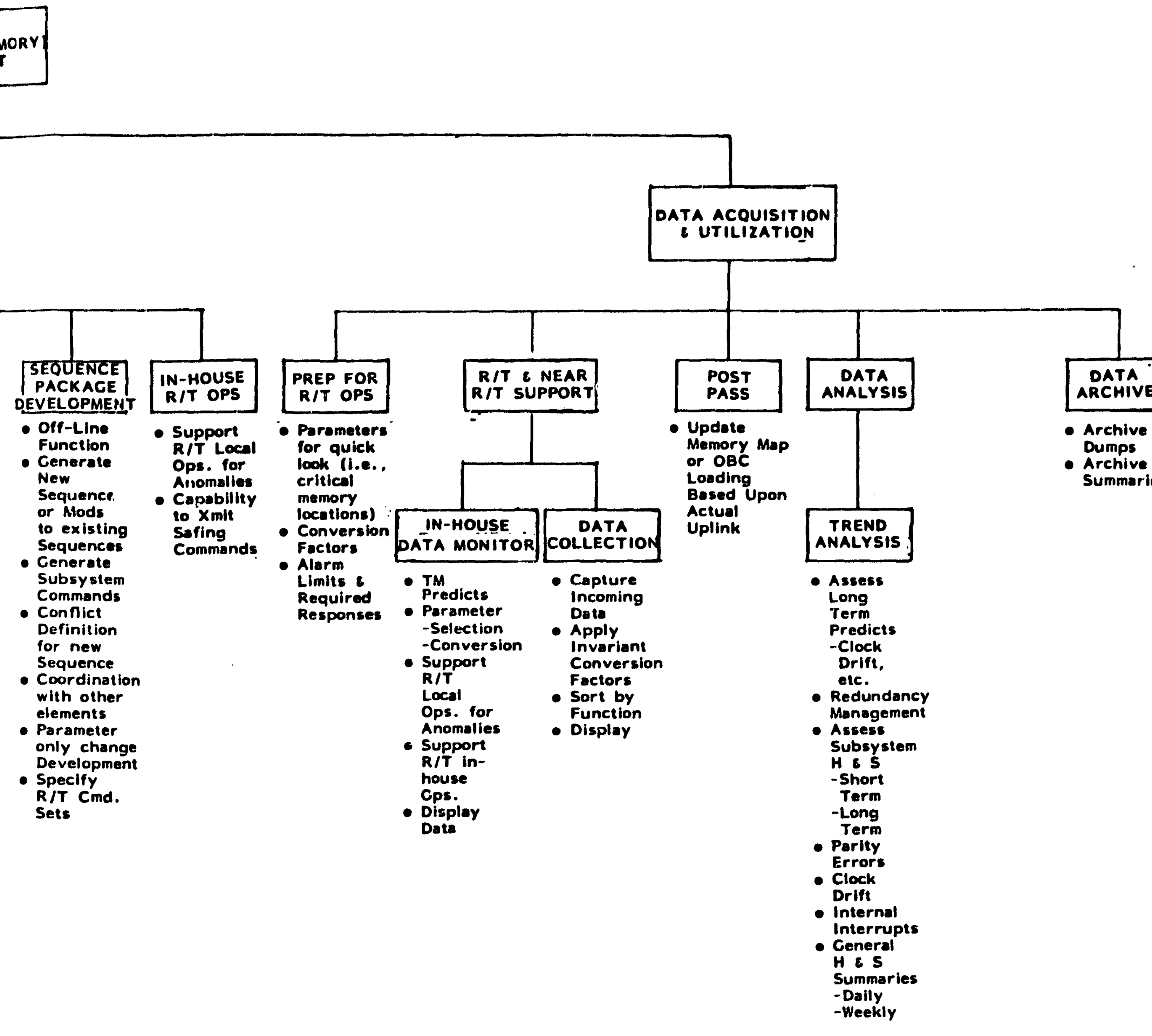

RY) MANAGEMENT FUNCTIONAL HIERARCHY

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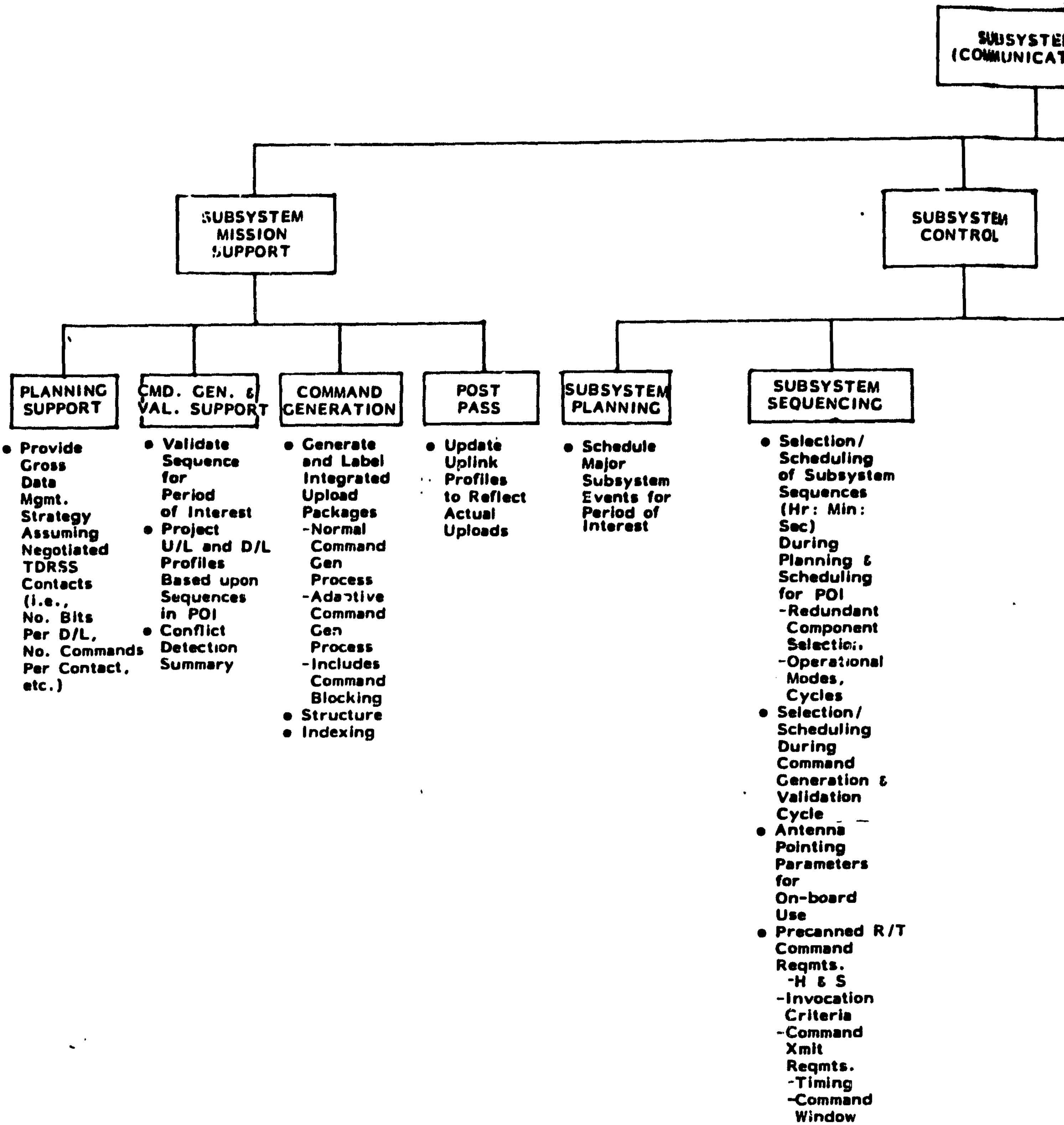

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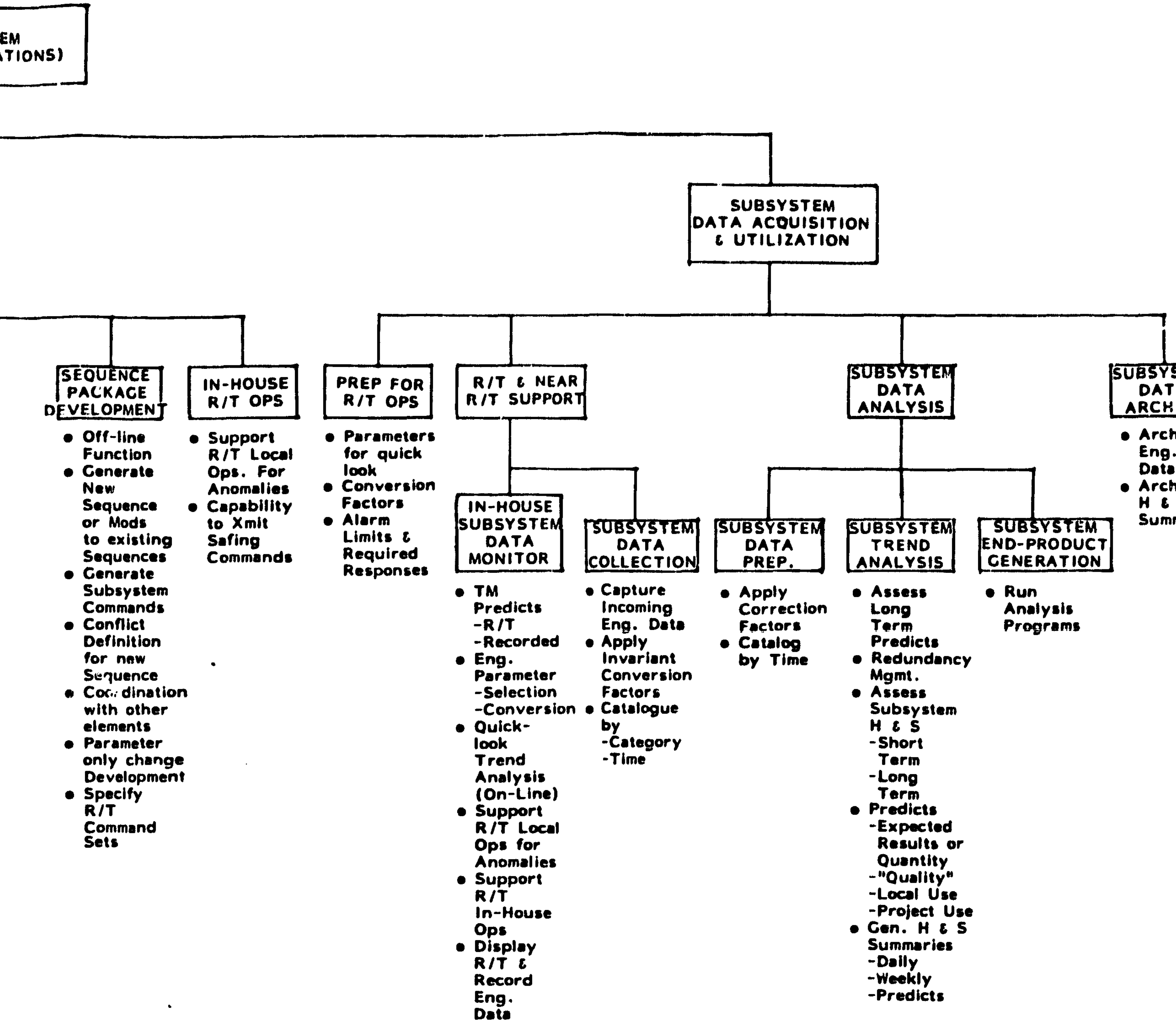
FIGURE 4.2-6 SUBSYSTEM



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(COMMUNICATIONS) FUNCTIONAL HIERARCHY

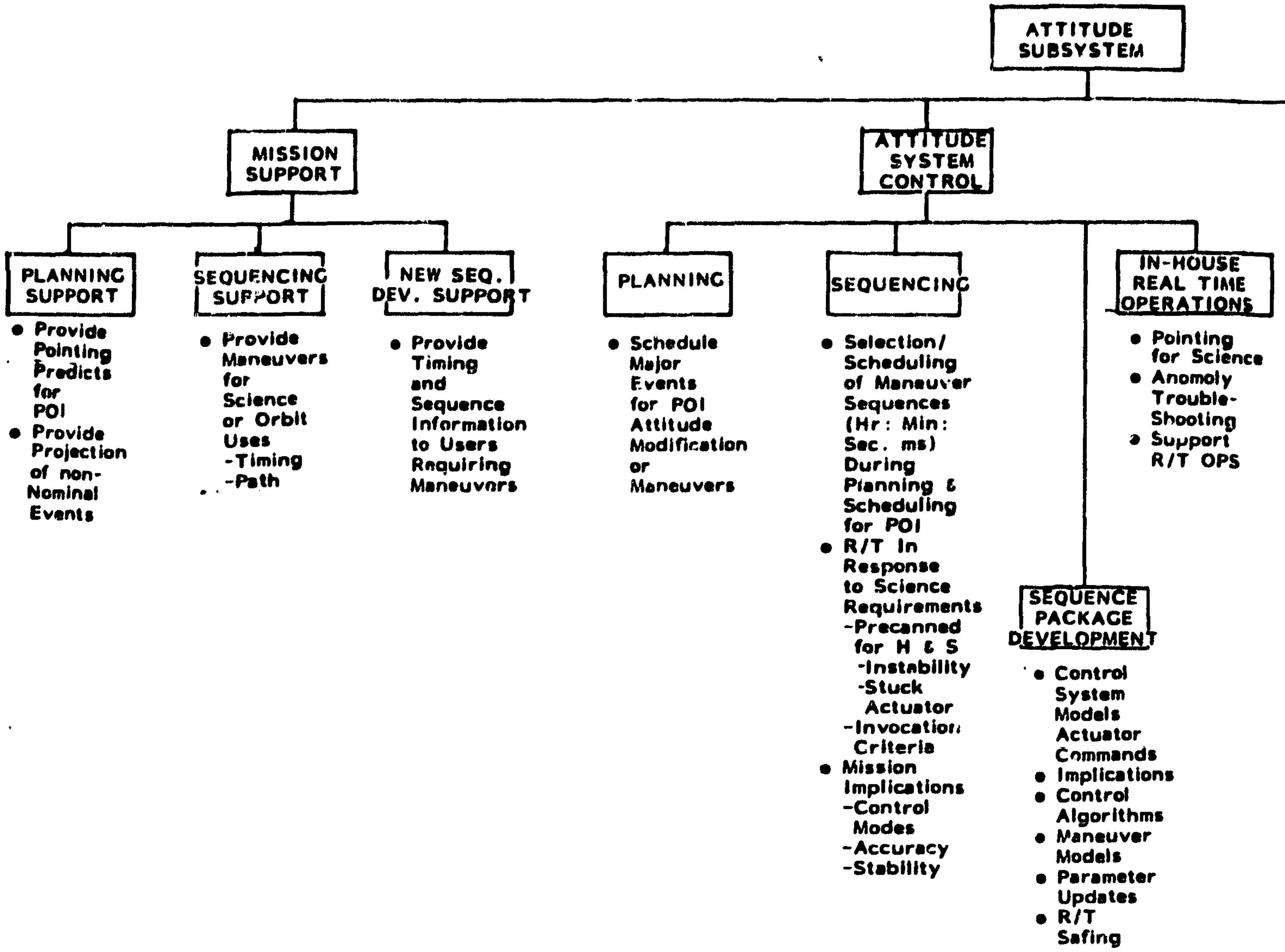

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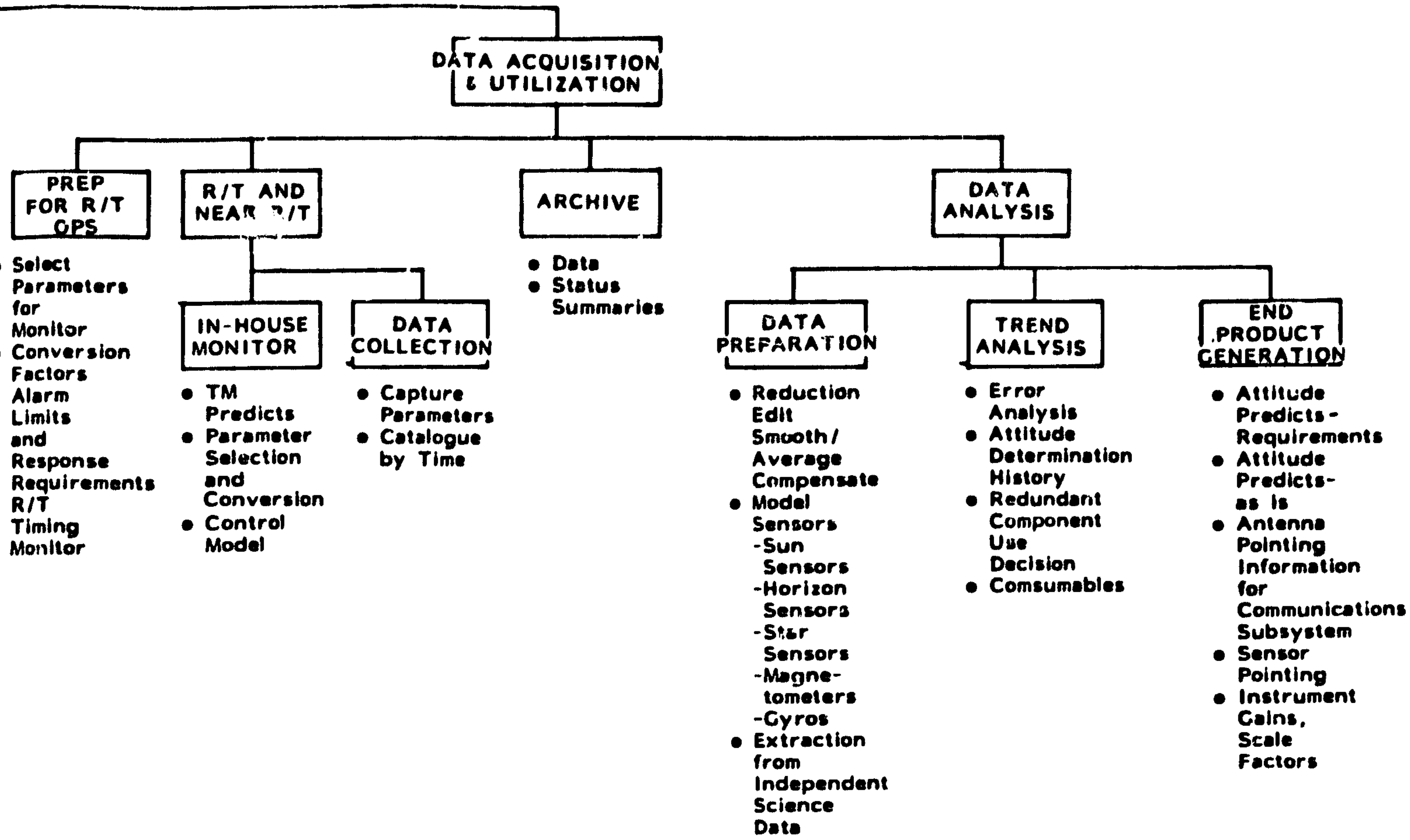
FIGURE 4.2-7 ATTITUDE SUB



STEM FUNCTIONAL HIERARCHY

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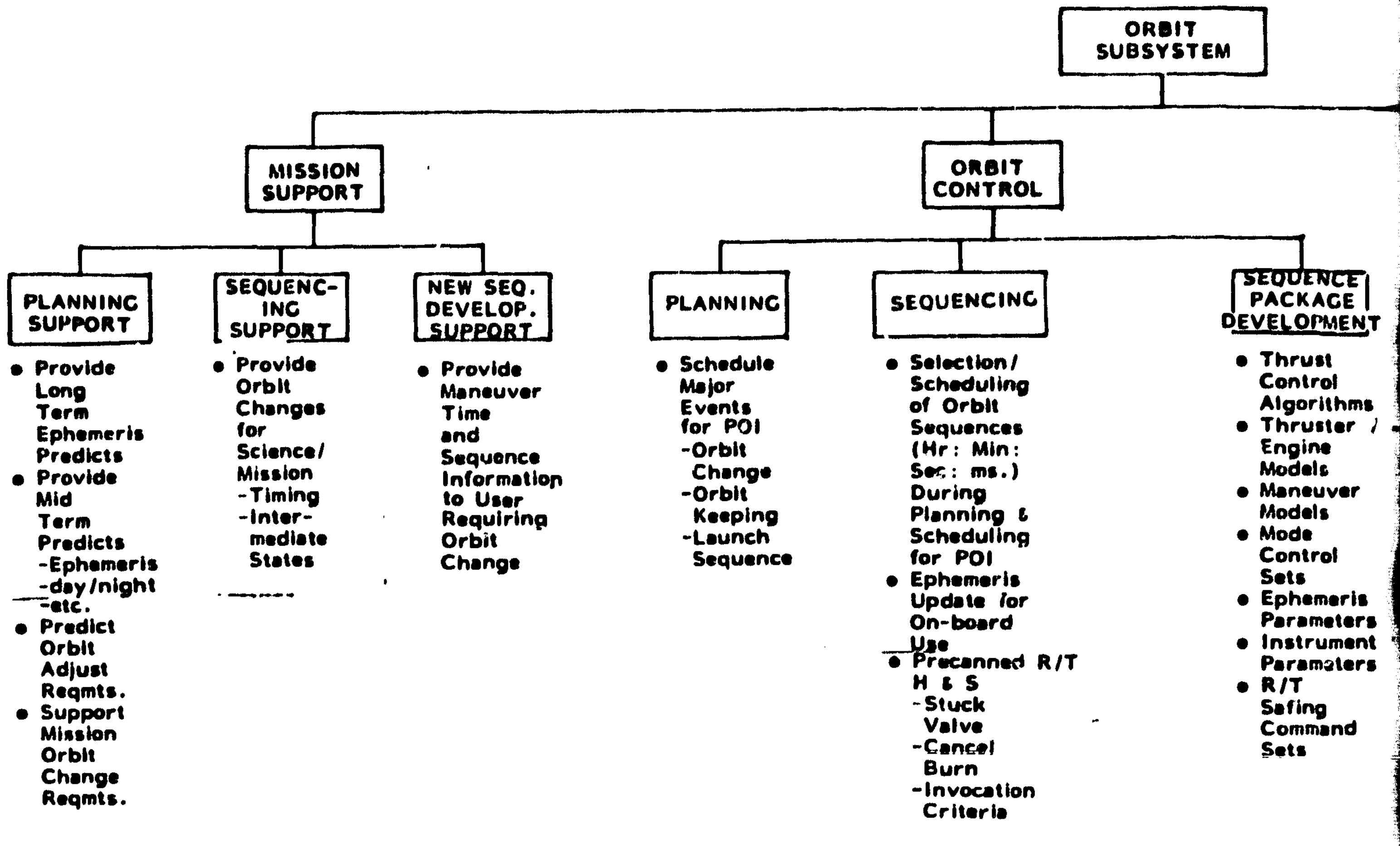

FIGURE 4.2-8 ORBIT SUBS

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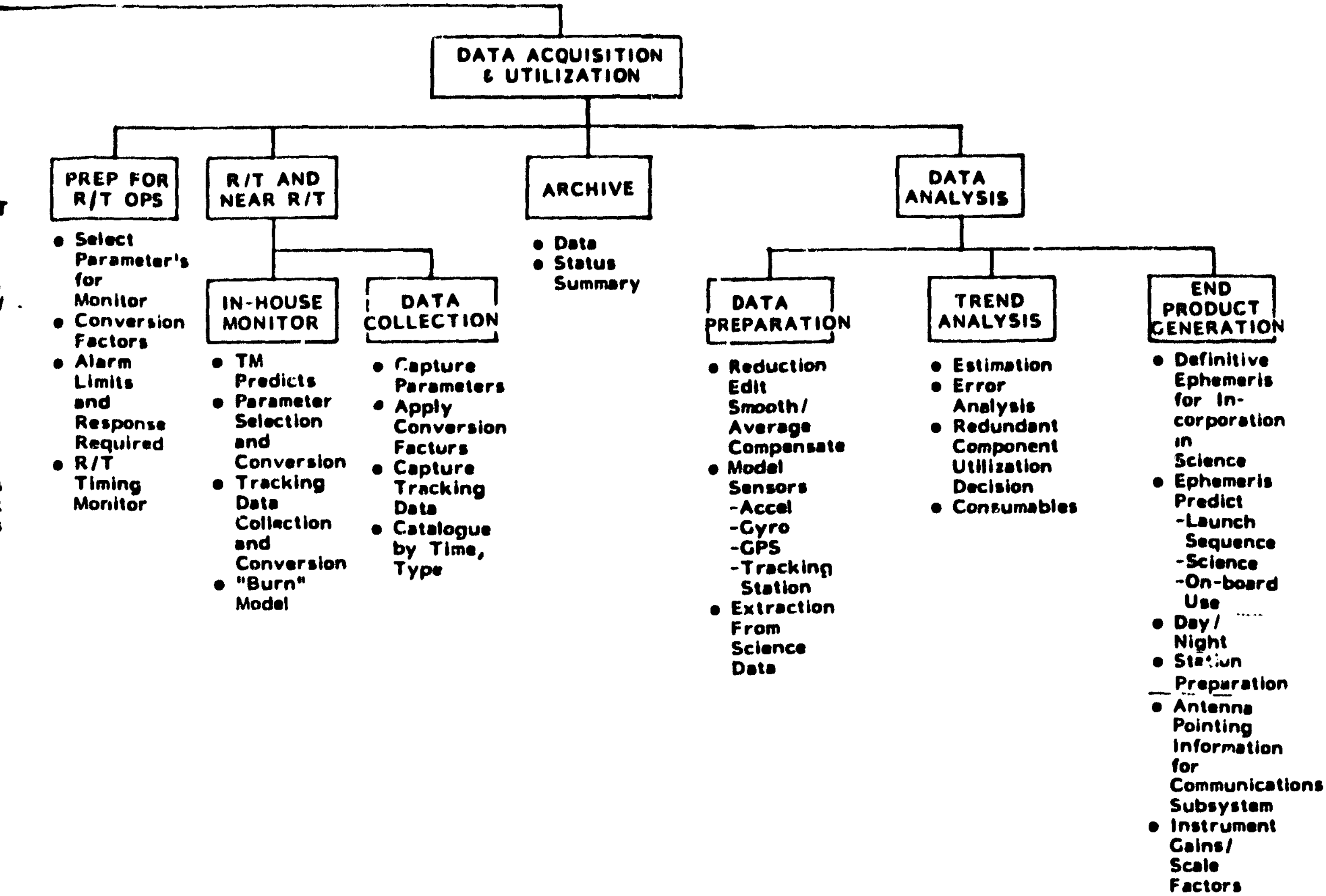

SYSTEM FUNCTIONAL HIERARCHY

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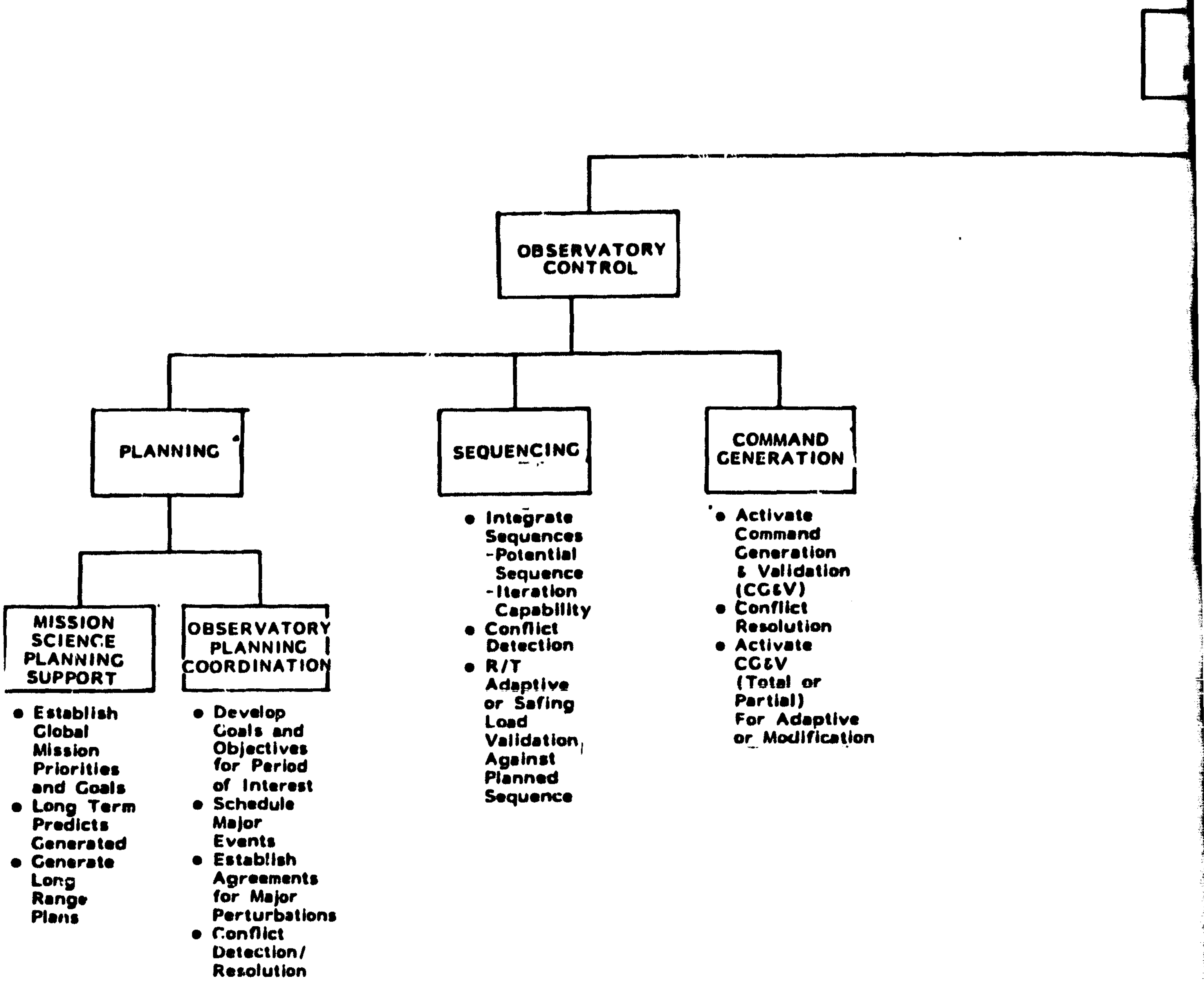

FIGURE 4.2-9 MISSION MANAGEM

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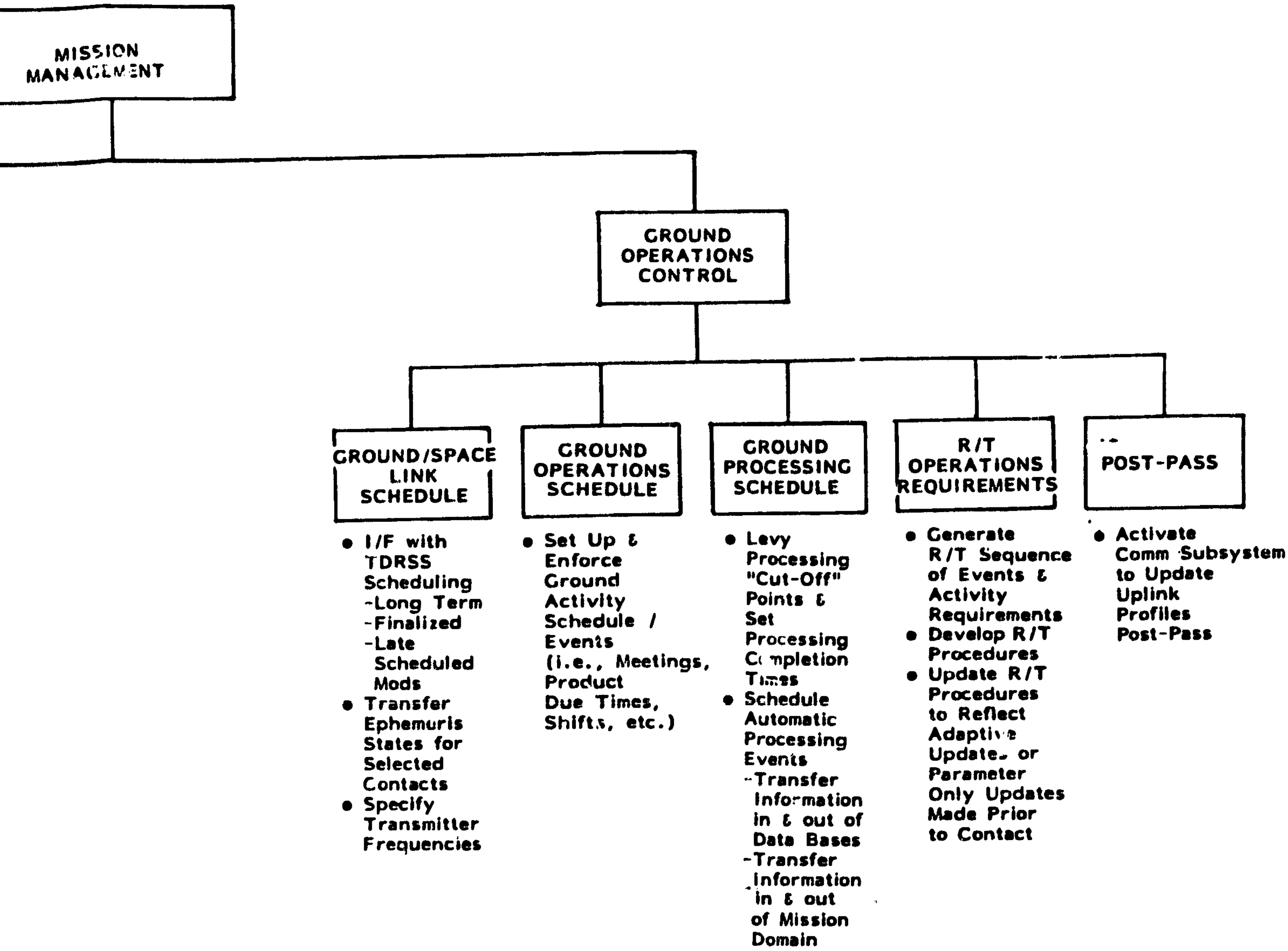

AGEMENT FUNCTIONAL HIERARCHY

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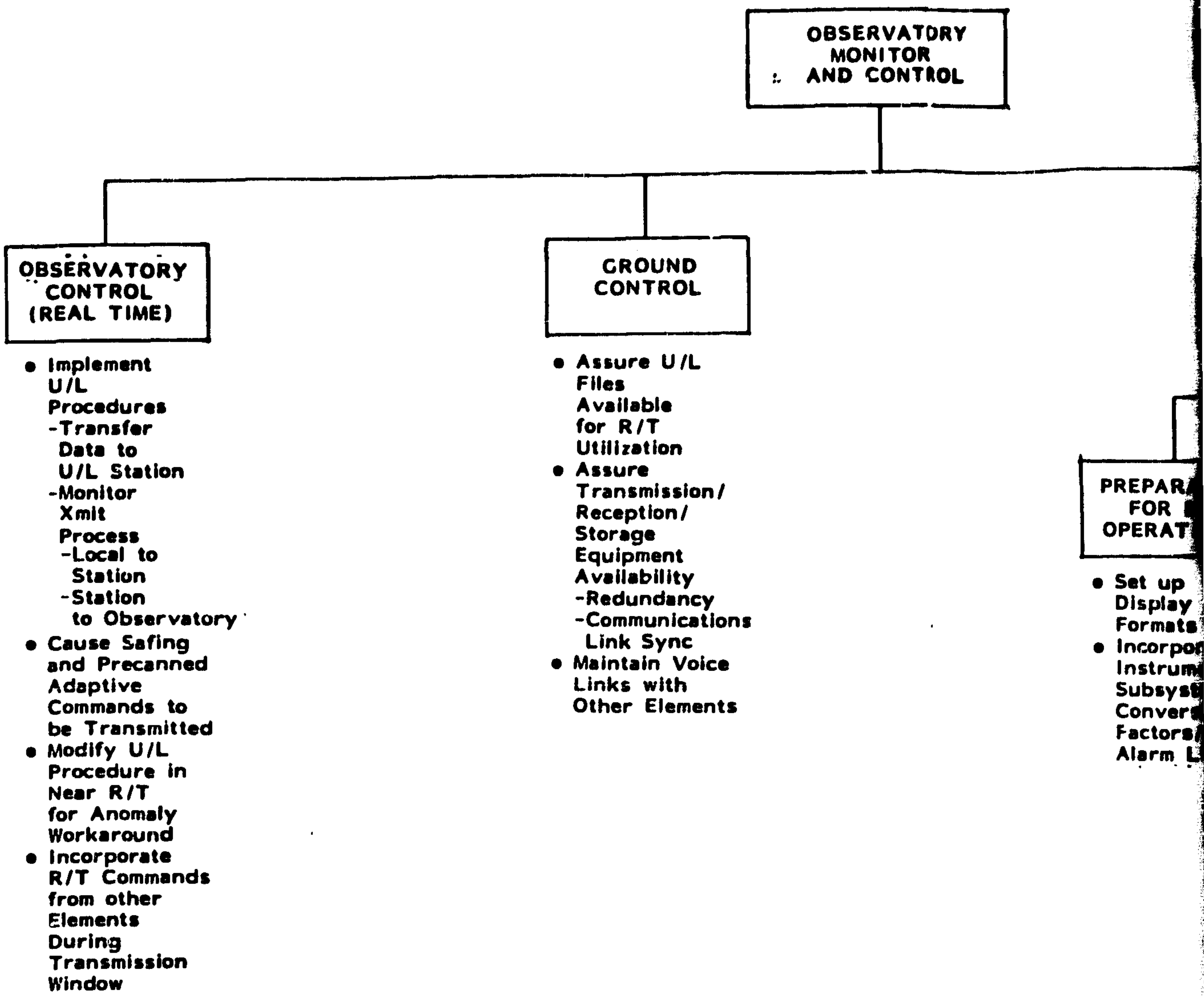

FIGURE 4.2-10 OBSERVATORY MONITOR AND CONTROL FUNCTIONAL HIERARCHY

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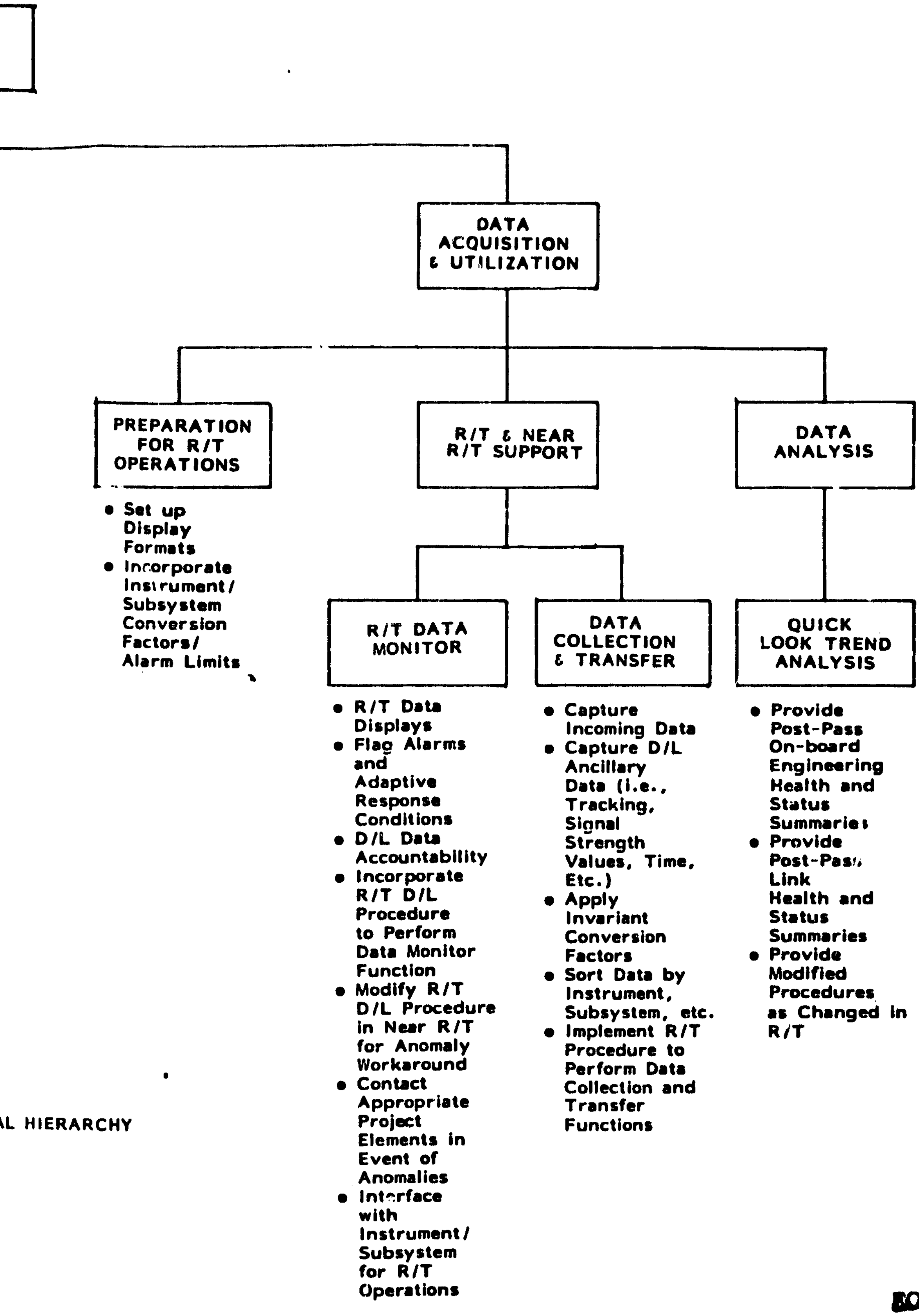

AL HIERARCHY

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Figure 4.2-II

INTERACTIVE USER

- USER INTERFACE IS A GRAPHIC TERMINAL TYPE DEVICE
- STANDARD DISPLAY PACKAGES USED THROUGHOUT IC^4 SYSTEM
- USER INTERACTS WITH SYSTEM AND OTHER USERS THROUGH TERMINAL - MENU SELECTION TECHNIQUE
- DISPLAYS - STANDARD ACCESS
  - SKELETONS FOR USER SPECIFIC DISPLAYS
  - USER CAN MERGE PORTIONS OF MULTIPLE DATA SETS TO PRODUCE MOST USEFUL ACTIVE DISPLAY
- INFORMATION ACCESS - BECAUSE OF STANDARD INTERFACES AND THE STANDARD DISPLAY FORMATS, USER MAY ACCESS ANY INFORMATION IN THE SYSTEM
- PROCEDURE ACCESS - STANDARD INTERFACES ALLOW USER ACCESS TO SYSTEM SOFTWARE AND PROCEDURES

is contained. Users can customize the contents of a data package; however, as data packages and display packages are synonymous, the general format is always known to all users. The system provides the capability to merge data from multiple packages as one display for comparison purposes. Displays can also be updated to generate new displays going back to the starting skeleton and starting from scratch.

The system provides the user the capability to access all information in the system and to present data to processes within the system. Thus, if a user has prepared a data package for processing, the package can be submitted to the standard IC^4 procedures directly by the user.

4.2.3.2 Sequence Packages

A prime example of the use of the interactive capabilities of the IC^4 system is the sequence package. As described in Figure 4 2-12, the sequence package is the standard data package used to specify activities which are required to be done on-board the observatory. For each activity required of a science instrument or spacecraft subsystem, a sequence package is generated. (For identical activities which occur at varying times, multiple sequence packages are generated which specify the desired time of execution of the activity.)

Figure 4.2-13 illustrates a portion of the graphical representation of a sequence package as it would be seen upon a terminal. A user fills in data such as the examples shown in this figure. For some items, such as the event timelines, a low granularity version (major events) and a higher granularity version (detailed events) actually

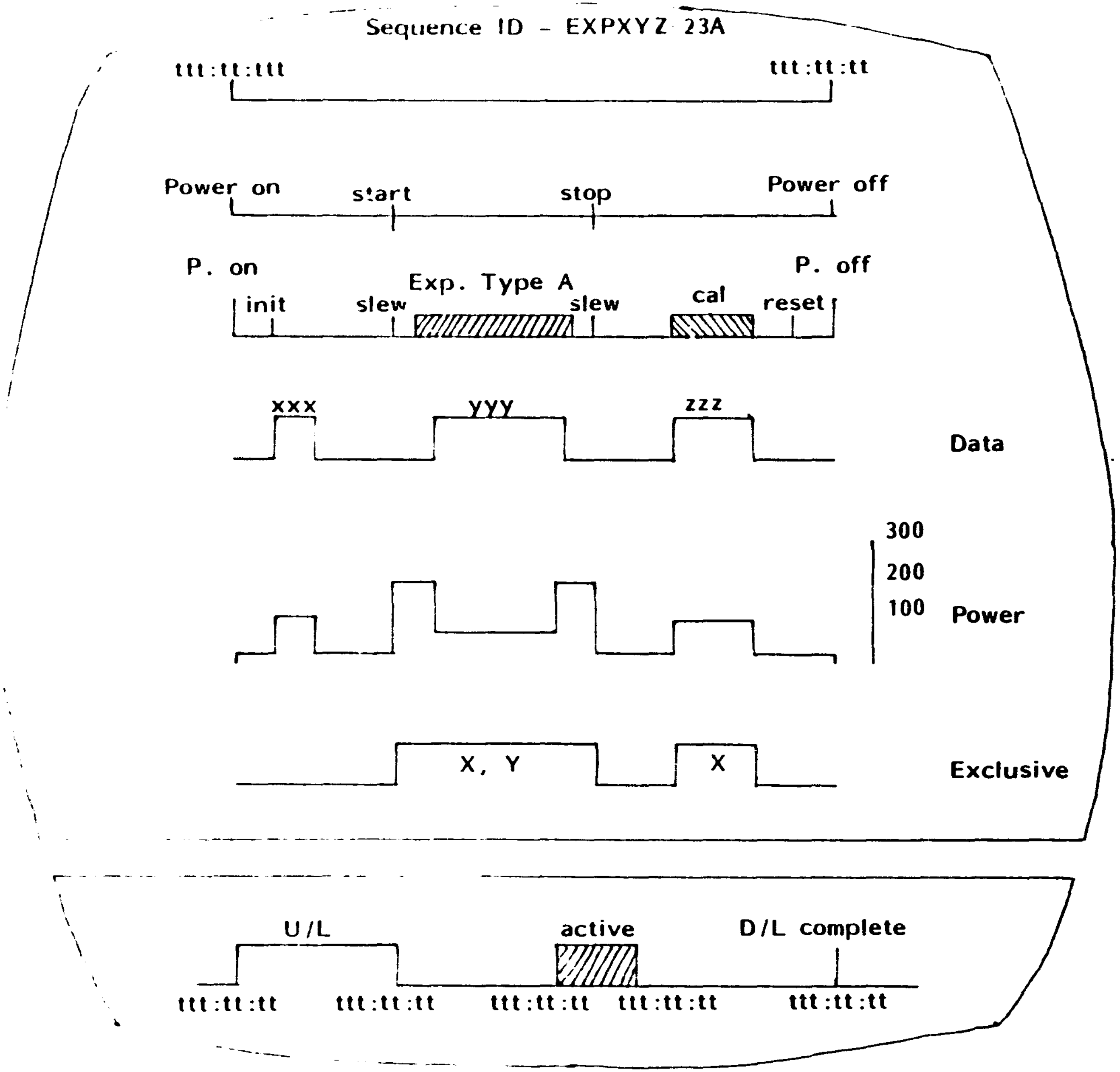
Figure 4.2-12

IC^4 SEQUENCE PACKAGE

- STANDARD INTERFACE BETWEEN USER AND SYSTEM TO SPECIFY REQUIRED ON-BOARD ACTIVITIES

- TOTALLY SPECIFIES ACTIVITY (I.E., CONTAINS ALL INFORMATION NECESSARY TO PLACE SEQUENCE IN PROPER LOCATION WITHIN A POI, INCLUDES ALL COMMAND TO OBSERVATORY, UPLINK AND DOWNLINK REQUIREMENTS AND USE OF OBSERVATORY CAPACITITES)

- ONE SEQUENCE PACKAGE PER SEQUENCE EXECUTION



DESCRIPTION

Time (granularity selectable)
(May be absolute or relative)

Major Event Timeline

Detailed Timeline

Periods of Data Transfer to Central Storage (xxx,etc = Subtotal, not always displayed)
(Similar for R/T Data Transfer)

Power Profile (Standard Scale)
(Similar for Thermal)

Mutually Exclusive Profile
(X,Y, etc. = Standard Designators)
(Similar for Required Spacecraft Activity Profile)

Command Window. Data Receipt Deadline (Note different time scale. Times would not be shown on high level graphic with common time line.)

FIGURE 4.2-13: Contents of a Sequence Package, Part I - Graphics

are the same data. The user or other users can select the timeline and specify which granularity they wish to have displayed. Similary, during early planning times, coarse granularity is all that is required; however, in order to generate the actual command load a detailed, completely specified timeline is necessary. Figures 4.2-14 and 4.2-15 illustrate the tabular version of the sequence package. The originator may choose to enter the data in a graphic or tabular form, and the system services will convert either form to the alternate presentation upon command. When a sequence package is completed it supplies all data necessary to generate a command file for uplink to the observatory and to perform a command generation and validation test.

4.2.3.3 Adaptive Update Capability

Figure 4.2-16 summarizes the types of adaptive updates that IC^4 system users may implement. Also, shown is the impact to the observatory sequence. Figure 4.2-17 summarizes the time periods during which users may institute these commands. Refer to Reference 3 for a detailed description of the user adaptive update capability.

4.2.3.4 User In-House Real-Time Operations Capabilities

Figure 4.2-18 summarizes the real-time operations capabilities provided to each user. These capabilities are defined in detail in Reference 3.

4.2.4 Operations Activity Threads

The following activity threads are provided below:

a. long range planning
b. planning and scheduling
c. command generation and validation
d. real-time operations

SEQUENCE PACKAGE
SUMMARY VALUES

ITEM	NAME	VALUE	DESCRIPTION
1	Sequence ID	EXPXYZ-23A	Identification of Sequence Package
2	Uplink Total	XXXX	Total Command Load for this Sequence
3	Rec'ed Downlink Total	YYYY	Schedulable Data Downlink
4	R/T Downlink Total	ZZ	Real-Time Downlink
5	Central Storage Total	XXXX	Data to be stored in Central Storage Facility
6	OBC Commands Total	YY	Number of Commands to be Executed by OBC (or Command Memory)
7	R/T Commands Total	0	Number of Commands to be Executed during the Command Window
8	Power Consumed Total	XX	
9	Thermal Load Total	YY	
10	Exclusive Periods	Yes/No	

FIGURE 4.2-14: Contents of a Sequence Package, Part II - Graphics (1 of 2)

SEQUENCE ID = EXPXYZ-23A

ITEM	NAME	TIME	COMMAND		DESCRIPTION
11	OBC Command Exec.	P. on + 0	XYZCMD 1		Mnemonics for OBC (or Command Memory) -similar for R/T
		P. on + XX:XX	XYZCMD 2		
12	XYZ Processor Exec.	P. on + XX:XX	STRT A		Mnemonics (or actual processor commands) for instrument or subsystem dedicated processor
		P. on + ZZ:ZZ	EXEC 3		
		P. on + YY:YY	SLEW Z		
		o	o		
		o	o		
		o	o		
		EARLIEST/START	LATEST/STOP		
13	U/L Window	X:XX:XX:XXX	Y:YY:YY:YYY		Defines when commands may be transmitted
14	D/L Window-Rec	N/A	Z:ZZ:ZZ:ZZZ		Defines when data must be collected on-ground
15	D/L Window-R/T	X:XX:XX:XXX	Z:ZZ:ZZ:ZZZ		Defines when data will be transmitted
		TIME	WATTS		
16	Power Consumed	P. on + XX:X	0.05		Describes Power Consumed - similar for Thermal, etc. (May be generated automatically from graphic or vice versa)
		P. on + YY:Y	1.25		
		o	o		
		o	o		
		o	o		
		TIME	AZ	EL	
17	Pointing Req.	P. on + XX:X	0°	90°	Coordinated with attitude control -similar for other S/C-wide req's or exclusive use. (May be a tabular or graphic copy of controlling subsystem's sequence package.)
		P. on + YY:Y	+60°	+80°	
		o	o	o	
		o	o	o	
		o	o	o	

FIGURE 4.2-15: (continued, 2 of 2)

Figure 4.2-16

TYPES OF ADAPTIVE UPDATES

ADAPTIVE UPDATE	IMPACT TO OBSERVATORY SEQUENCE
SEQUENCE MODIFICATION	POTENTIAL IMPACT TO ALL OBSERVATORY EVENTS (IOS)
PARAMETER CHANGE	NO IMPACT
PARAMETER REMOVE	POTENTIAL IMPACT TO OBC OR COMMAND MEMORY
PARAMETER ADD	• POTENTIAL IMPACT TO OBC OR COMMAND MEMORY - Add if Enough Memory - Update Map Post Contact • REQUIRES U/L CAPACITY
PRECANNED ADAPTIVE COMMANDS	• POTENTIAL IMPACT TO IOS - Validated Prior to Contact • REQUIRES U/L CAPACITY
PRECANNED PARAMETER ADD COMMANDS	• POTENTIAL IMPACT TO OBC OR COMMAND MEMORY - Add if Enough Memory - Update Map Post Contact • REQUIRES U/L CAPACITY
PRECANNED HEALTH AND SAFETY	• POTENTIAL IMPACT TO IOS

Figure 4.2-17

ADAPTIVE UPDATE CAPABILITY

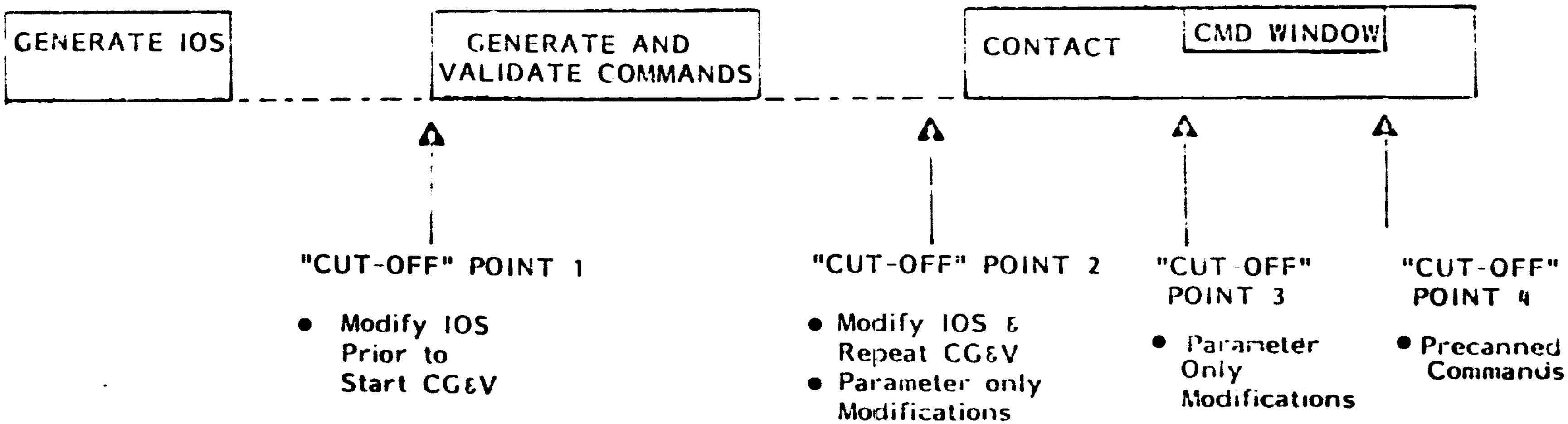


Figure 4.2-18

USER IN-HOUSE R/T OPERATIONS CAPABILITIES

MONITOR R/T DATA

- SELECT R/T DISPLAYS
- SELECT RAW TM (USER UNIQUE): R/T OR RECORDED
- VOICE COMMUNICATION WITH LOCAL OPERATIONS

INSTRUMENT/SUBSYSTEM CONTROL

- SELECT PRE-CANNED COMMANDS
  - PARAMETER MODIFICATIONS
  - ADAPTIVE SCIENCE SEQUENCE COMMANDS
  - HEALTH AND SAFETY
- VOICE COMMUNICATION WITH LOCAL OPERATIONS

USER FACILITY

- REMOTE OR CO-LOCATED
- INTERACTIVE TERMINAL

4.2.4.1 Long Range Planning

Figure 4.2-19 summarizes the long range planning activities. Refer to reference 3 for a detailed description of long range planning.

4.2.4.2 Planning and Scheduling

Figure 4.2-20 summarizes the planning and scheduling activities for the planning period of interest. Figure 4.2-21 illustrates the capability to modify the observatory sequences once they have been generated. These activities are defined in Reference 3.

4.2.4.3 Command Generation and Validation

The command generation and validation activity thread and the thread to implement parameter updates are summarized in Figures 4.2-22 and 4.2-23, respectively. The detailed activities are defined in Reference 3.

4.2.4.4 Real-Time Operation

The real-time operation for both local operations and in-house user operations are summarized in Figure 4.2-24. The detailed activities are defined in Reference 3.

4.2.5 Interfaces

Figure 4.2-25 summarizes the interfaces for the IC^4 system. For each number indicated, detailed interface descriptions were generated. Table 4.2-1 is an example of an interface description, in this case a portion of

number 6A (science experimenter to mission management). Reference 3 contains the detailed description for all of these interfaces.

Figure 4.2-19

LONG RANGE PLANNING

- ESTABLISH MAJOR MISSION EVENTS
- PERFORMED AS REQUIRED THROUGHOUT MISSION
- MANUAL OPERATION
- NOT A DRIVER TO IC^4 SYSTEM

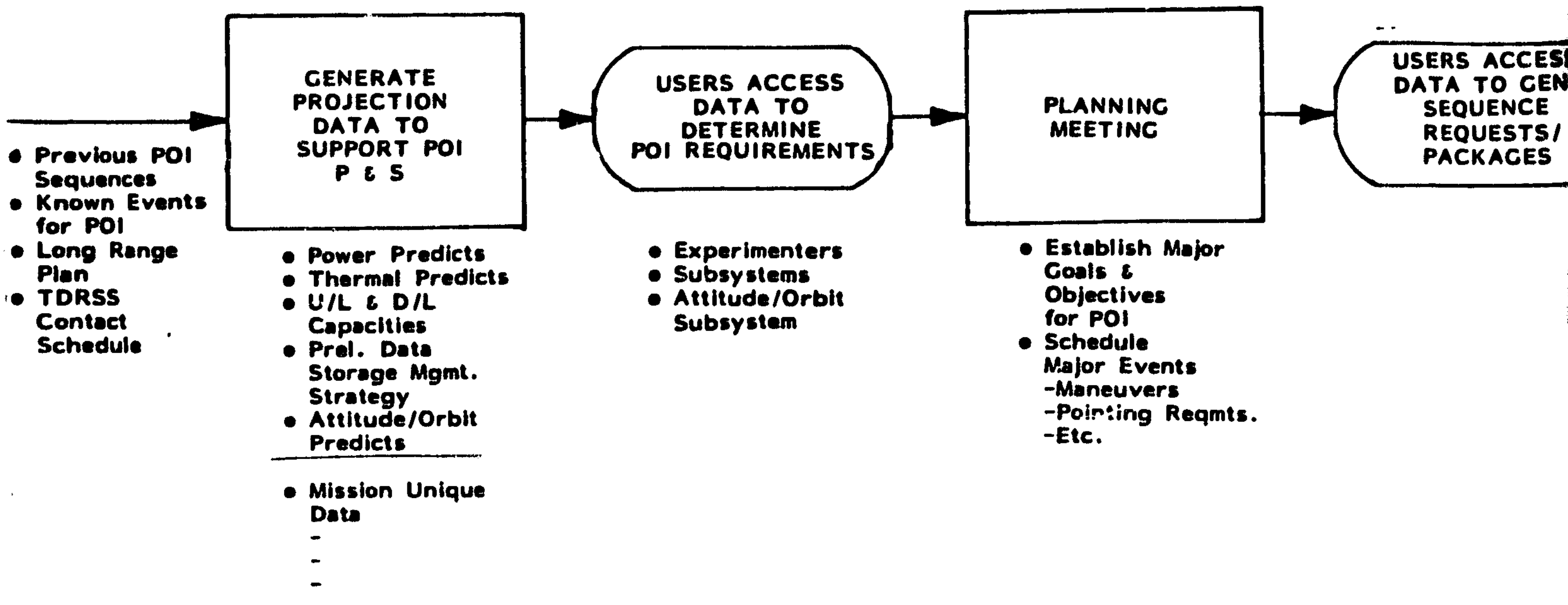


FIGURE 4.2-20 PLANNING AND SCHEDULING FOR PERIO

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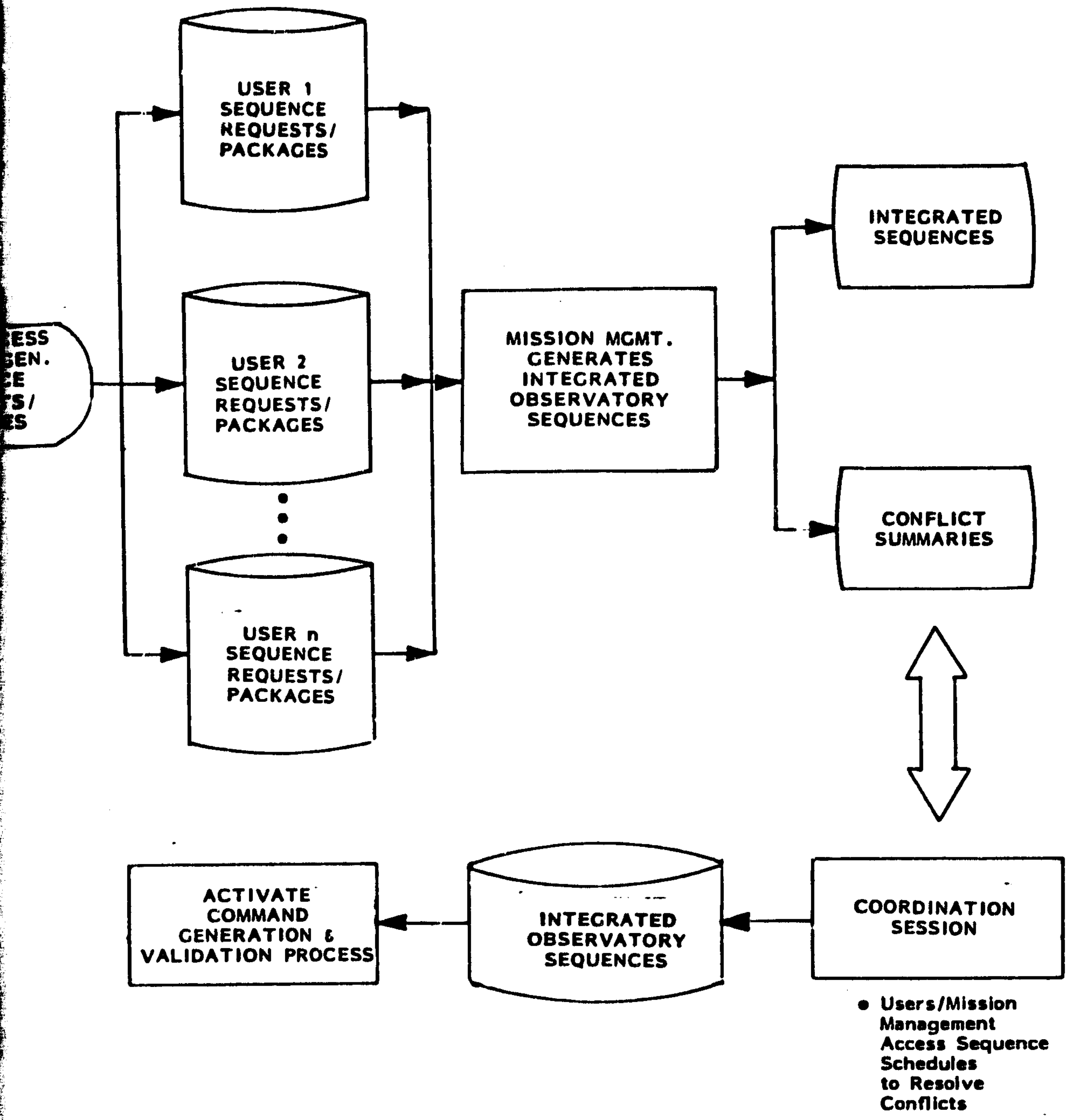

PERIOD OF INTEREST

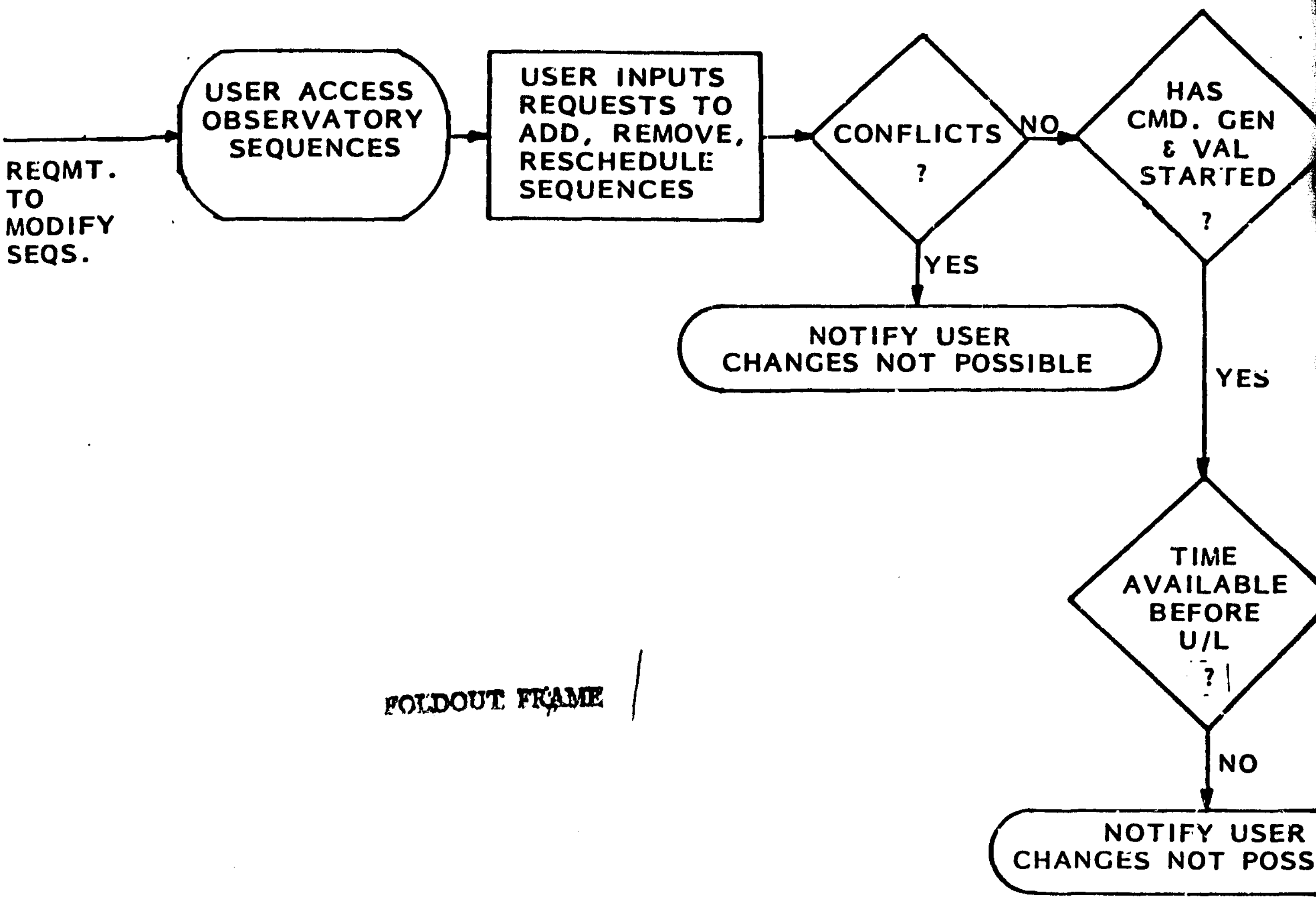

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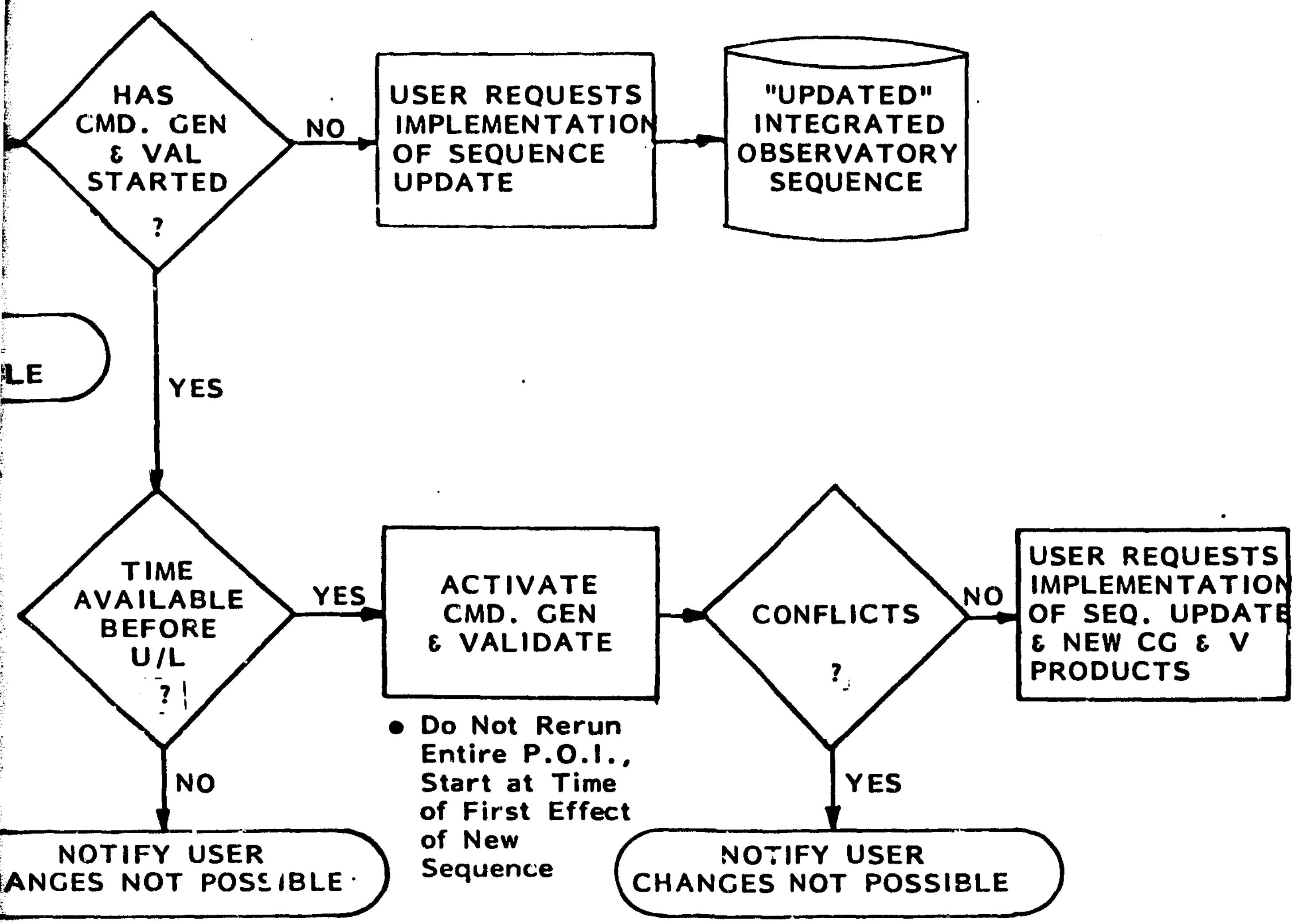
FIGURE 4.2-21 : USER UPDATE CAPABILITY TO OBS



PABILITY TO OBSERVATORY SEQUENCES

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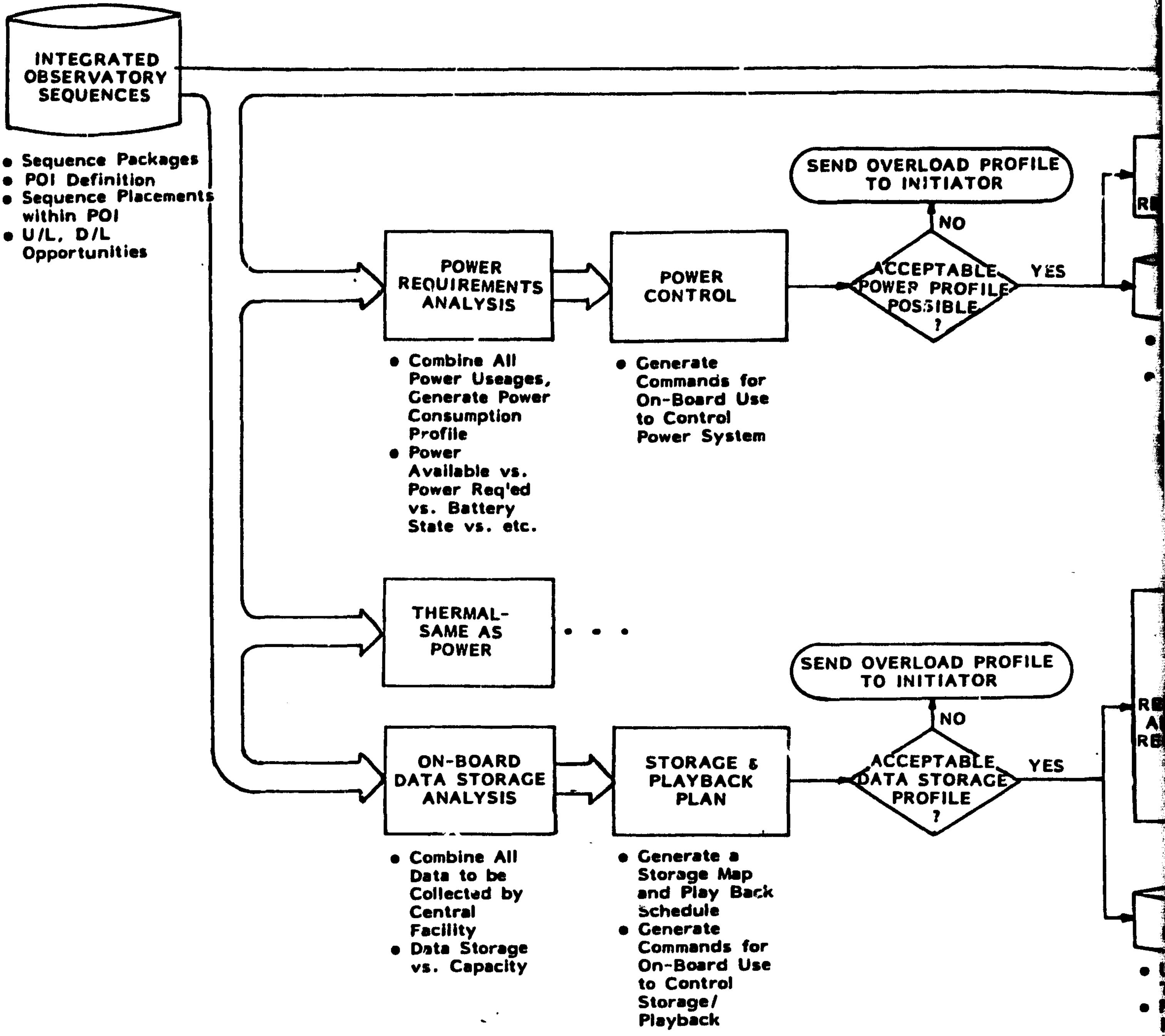

FIGURE 4.2-22 COMMAND GEN

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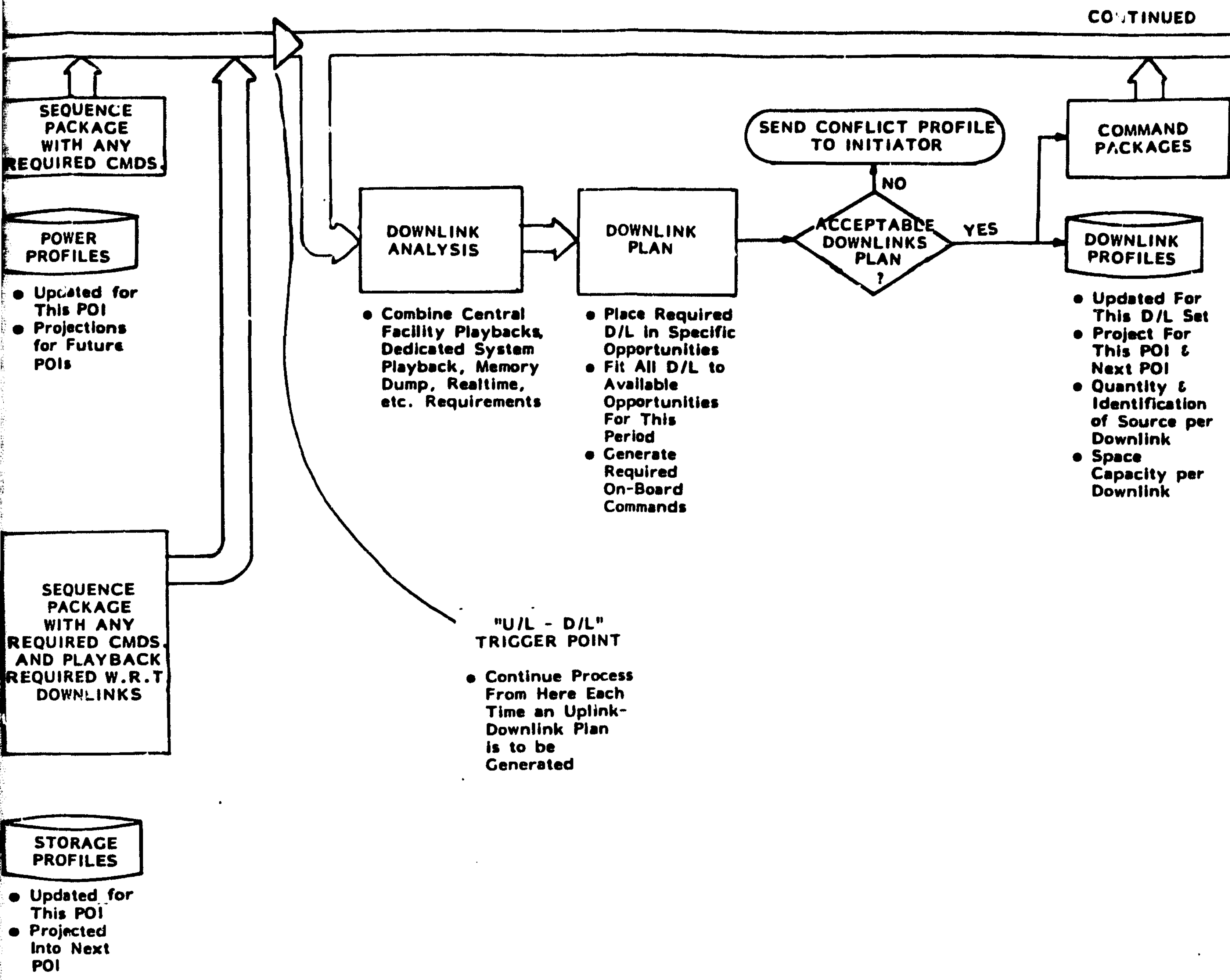

ENERATION AND VALIDATION (CG&V) PART 1

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(CONTINUED FROM PART I)

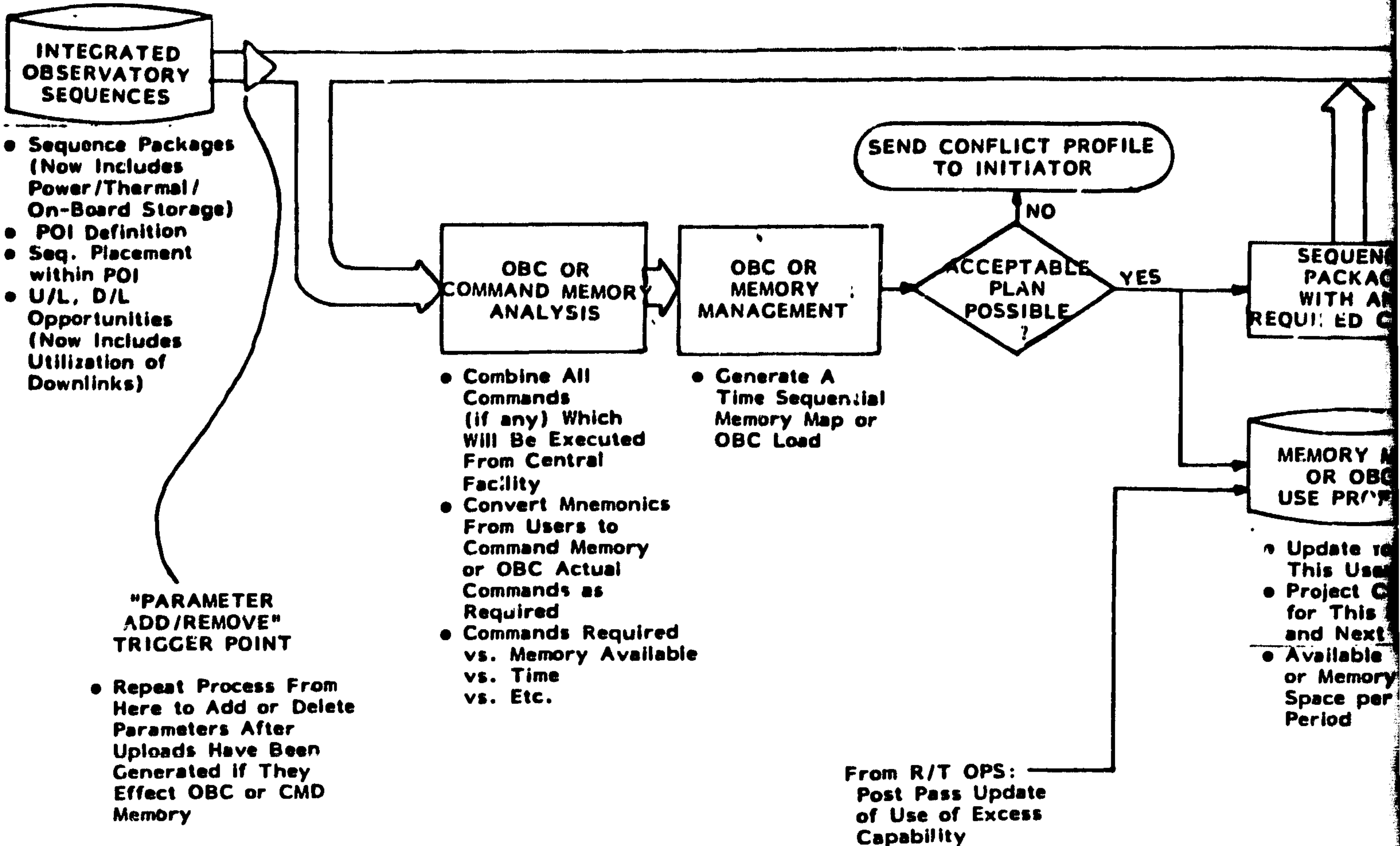
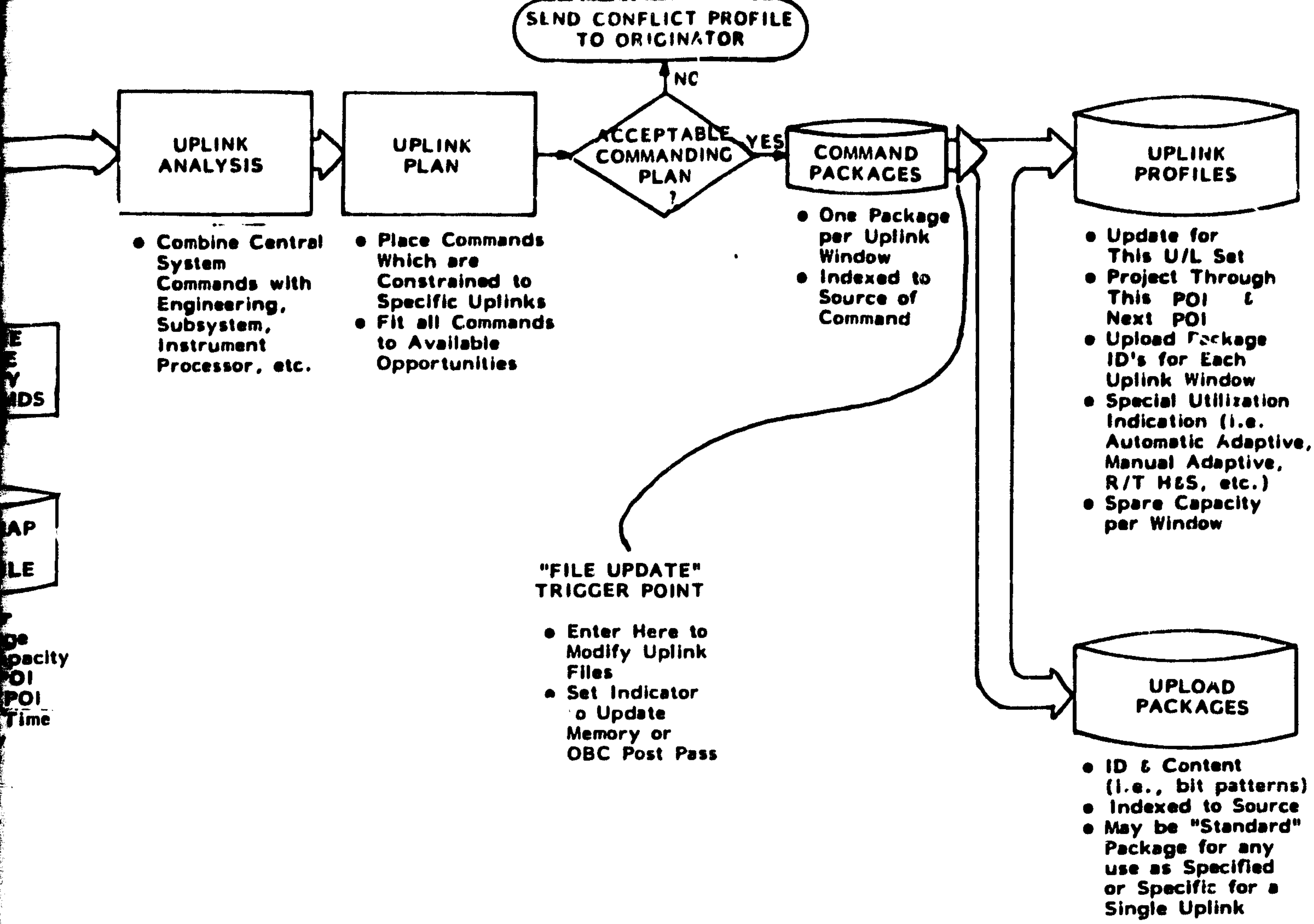


FIGURE 4.2-22 (continued) COMMAND GENERATION AN



D VALIDATION PART II

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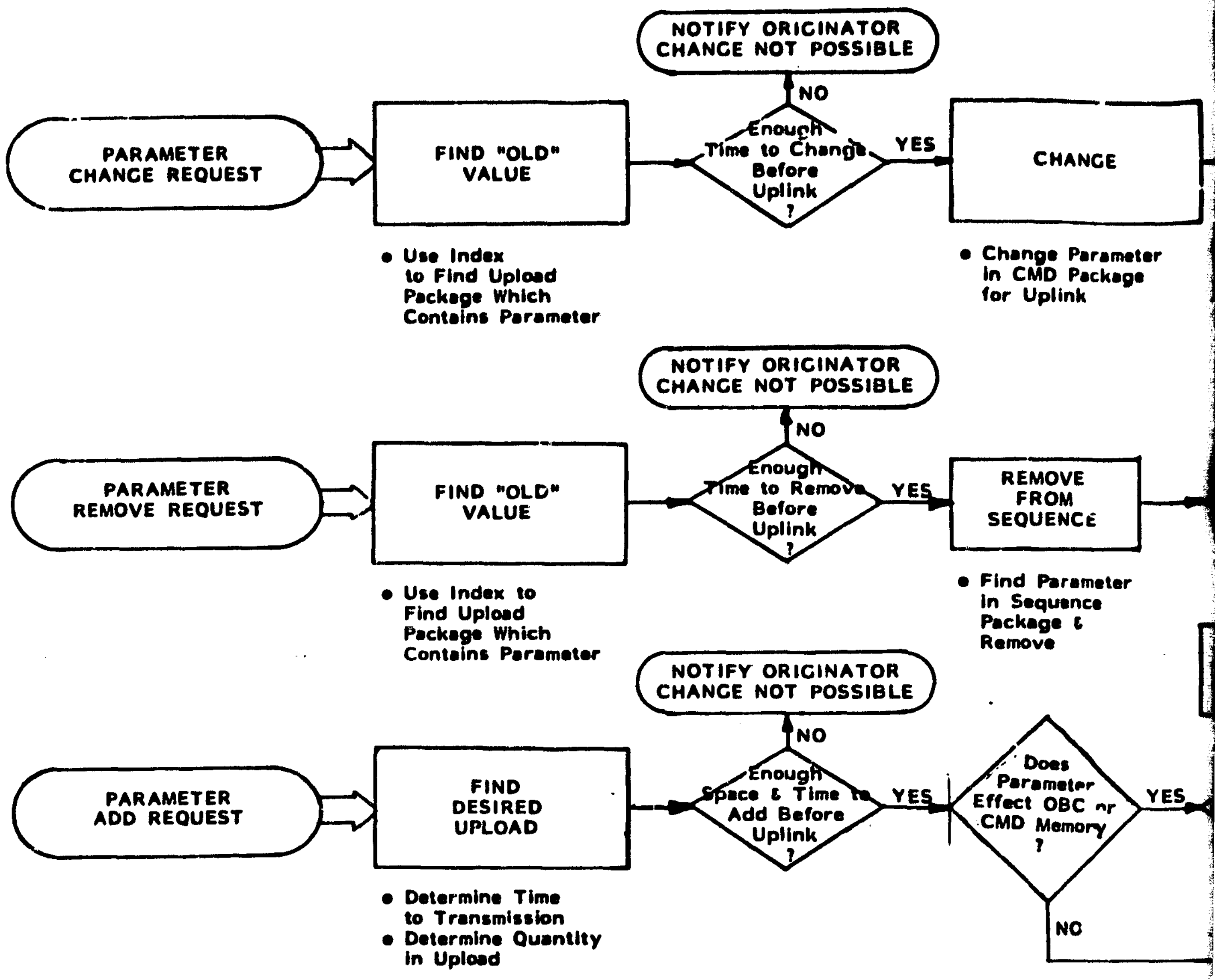

FIGURE 4.2-23 COMMAND GENERATION AND VALIDATION PART III (PARAMETER UPDATE IMPLEMENTATIONS)

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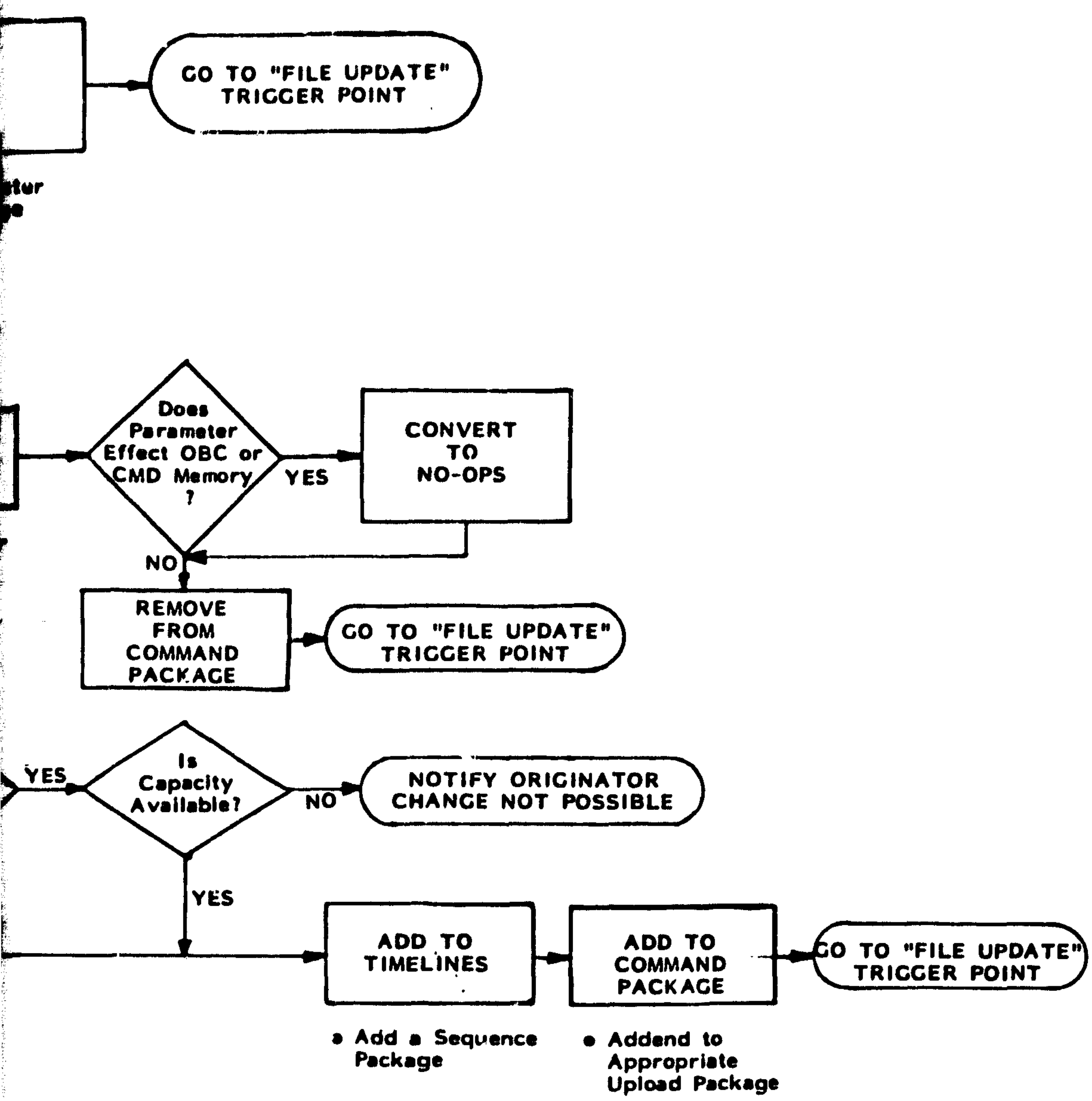

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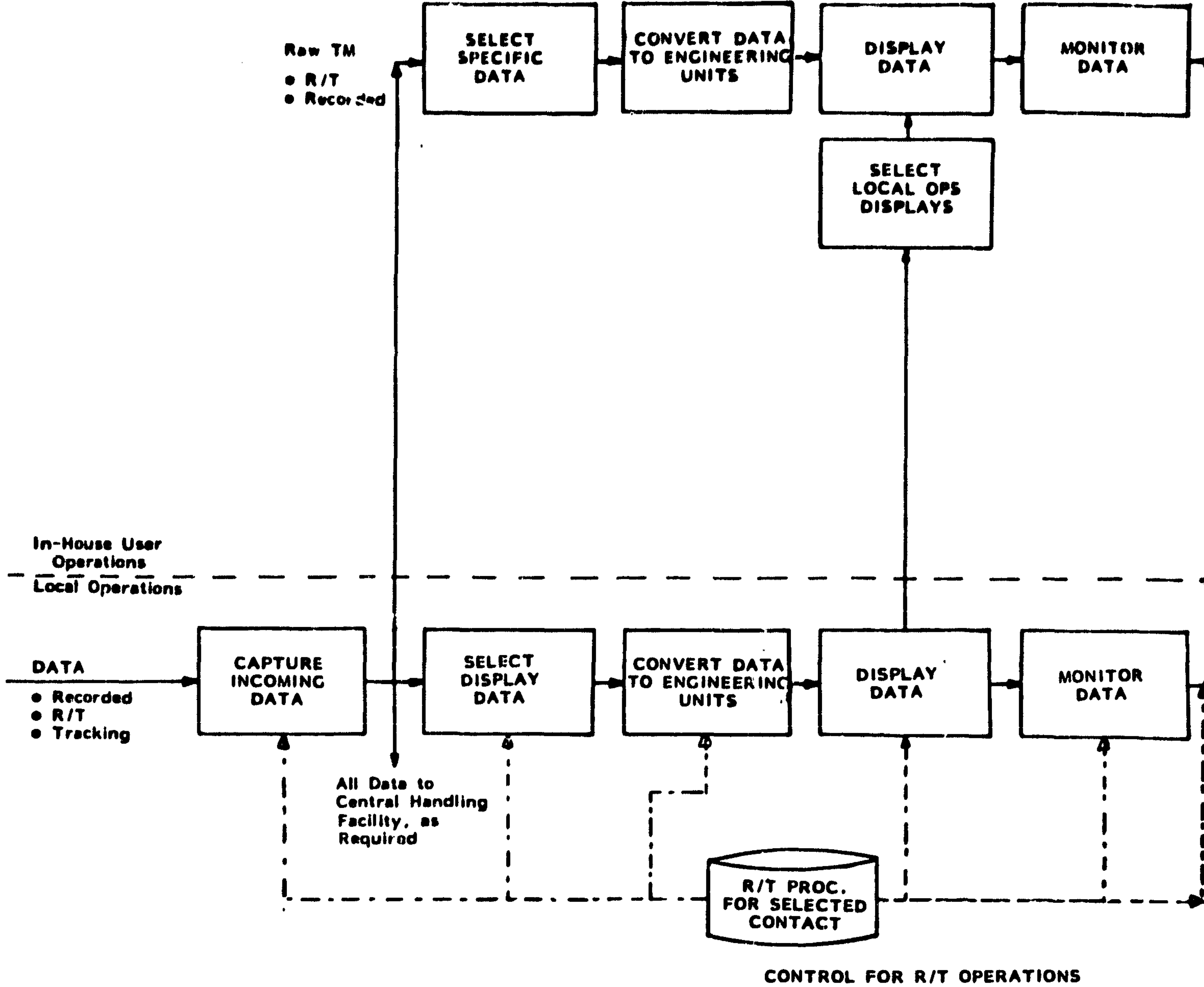

FIGURE 4.2-24 REAL TIME OPERATIONS (PASS ACTIVITIES)

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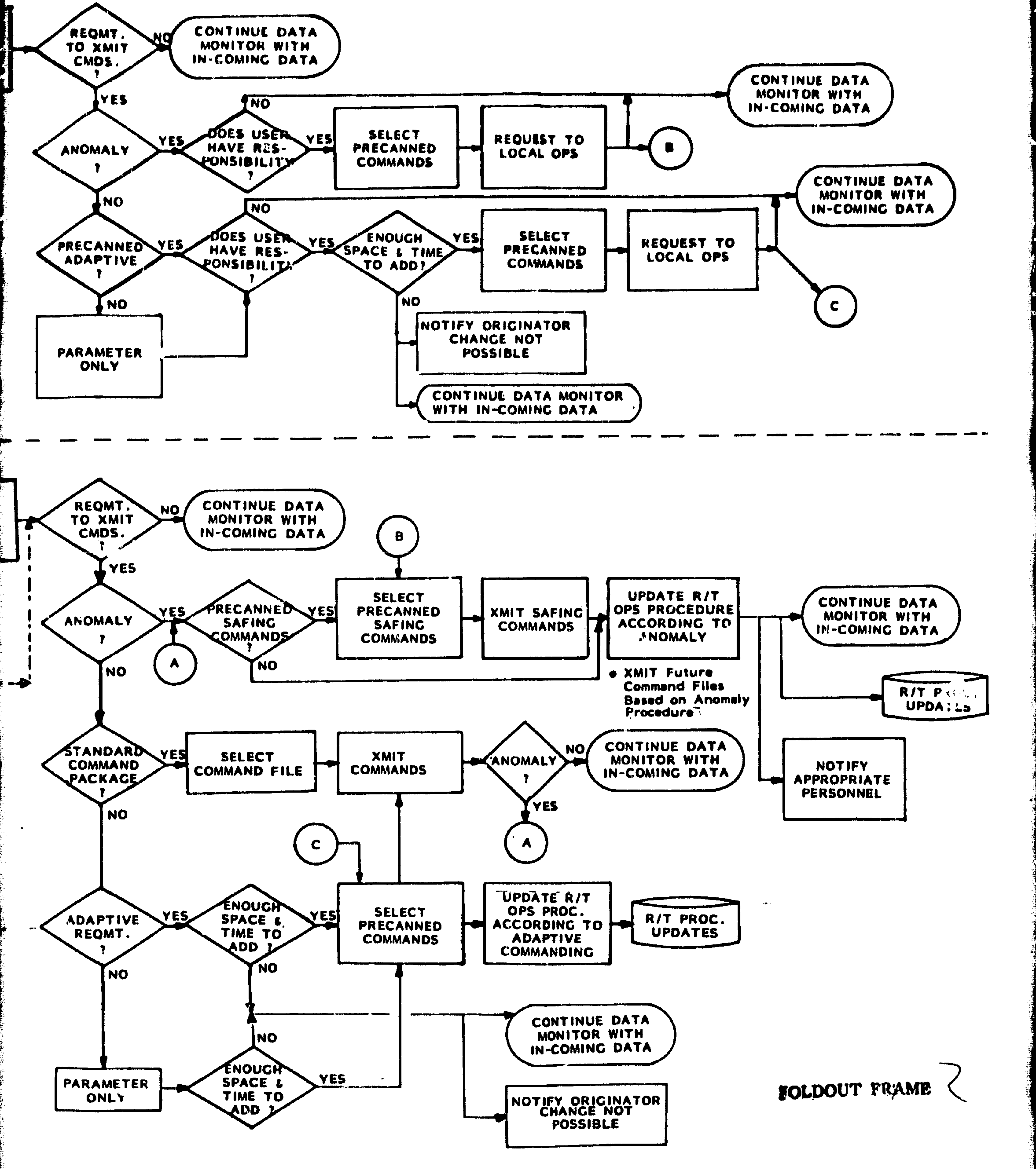

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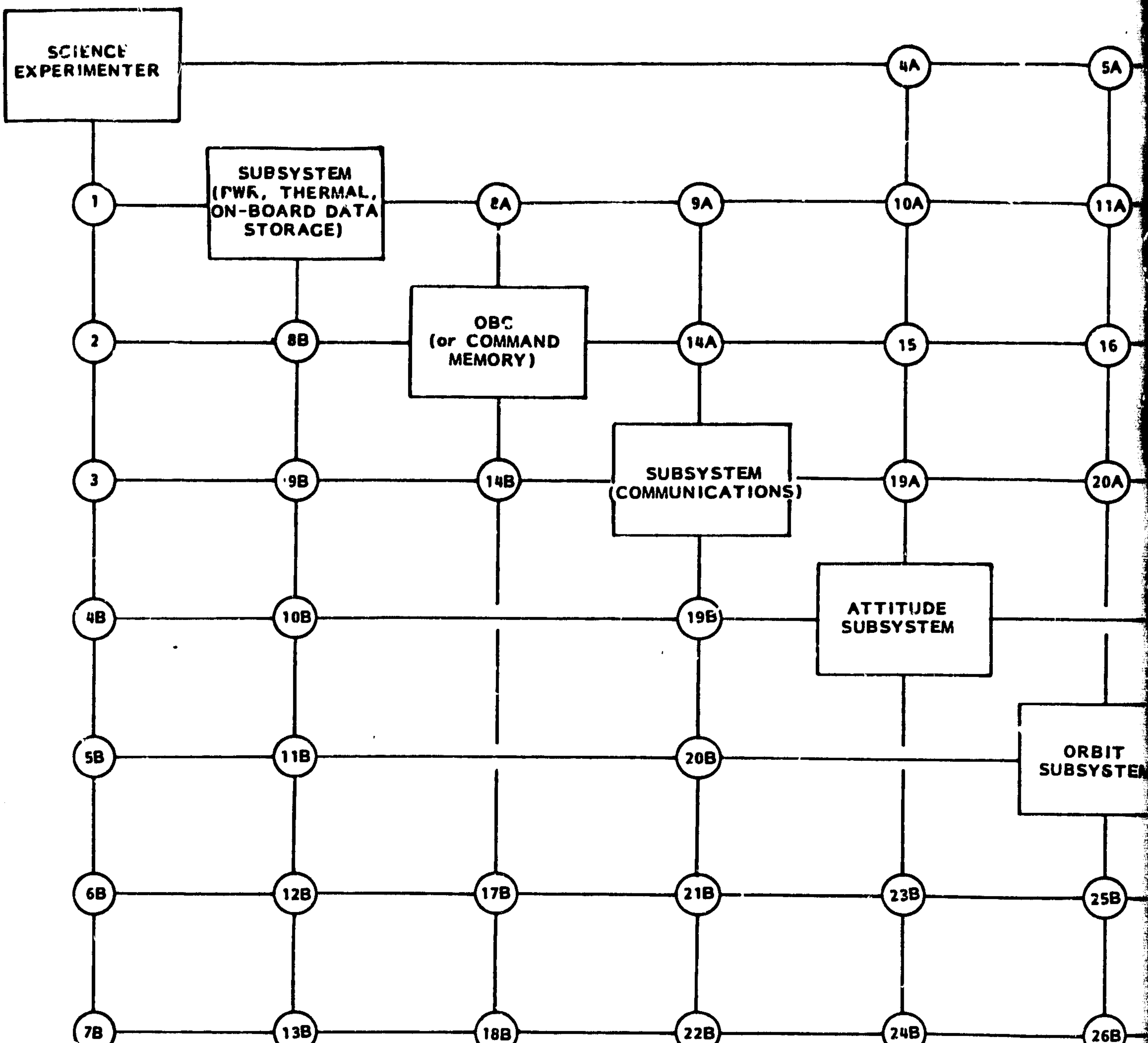

FIGURE 4.2-25 IC⁴ SYSTEM INTERFACES

Note: Interface numbers refer to Table numbers in text.

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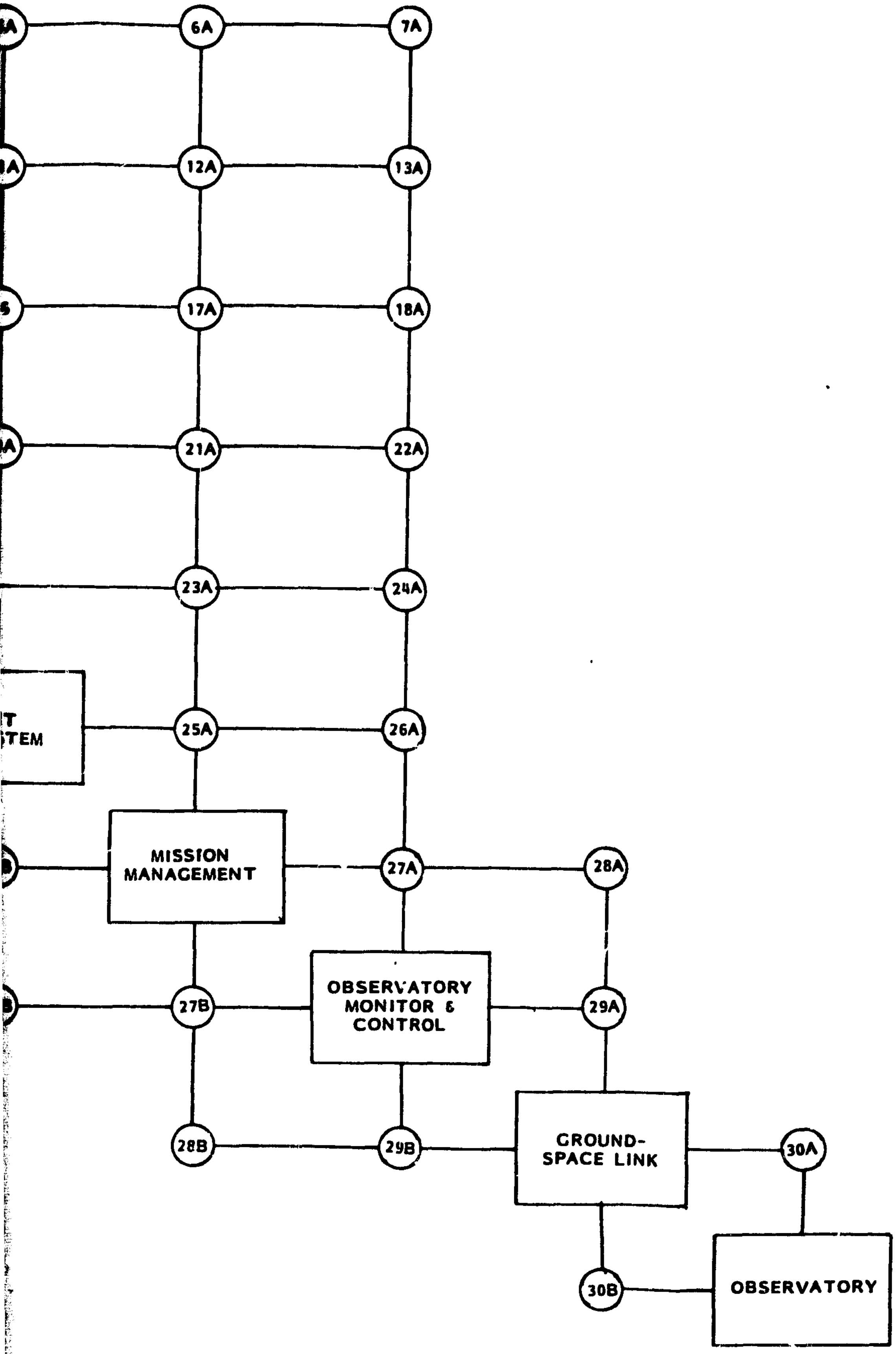

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Table 4.2-1

EXAMPLE INTERFACE: SCIENCE EXPERIMENTER TO MISS[illegible] MANAGEMENT

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Mission Science Planning	• Science Experiment requirements/desires for long range • Modified requirements based on conflicts	Person-Person (face-to-face/meeting)	Mission Science Planning Support
Science Instrument Planning	Instrument requirements for POI - major instrument events - data/commanding requirements - etc.	• Person-Person (Voice Communication) or • Man-machine (Exp creates data set containing requirements)	Observatory Planning Coordination
	Modified instrument requirements based on discussions during Planning Meeting	• Person-Person (Voice Communication) or • Man-machine (Experimenter creates data set modifying requirements)	Observatory Planning Coordination
Instrument Sequencing	Instrument sequence requests for POI or H&S or adaptive sequence	Machine-machine (Data access)	Sequencing
	Sequence package (per seq. requests)	Machine-machine (Data access)	
	Discussions concerning observatory sequence conflicts	Person-Person (Voice communication)	
	Request to activate Mission Management to generate "potential" observatory sequence using modified sequence requests	Man-machine (Man directs activity; data entry)	

5.0 DESIGN PLAN PHASE

The IC^4 system design plan was defined in the July status report (Reference 1). This section provides a synopsis of the IC^4 system design plan.

The effort to design the IC^4 system detailing hardware and software components and personnel activities will be conducted in two phases. Phase 1 will define and design a basis IC^4 system which is a command and control system that is common for all GSFC missions. The basis IC^4 system then becomes a standard and precanned set of capabilities, functions, hardware and software that can be used by multiple mission disciplines. During Phase 1 the basis IC^4 system will be defined and the design of the detailed personnel activities, software modules and hardware components will be accomplished. Architecture design trades will be performed as necessary to affect the system design. Inherent in the IC^4 functional architecture are mission unique capabilities that are not applicable for all missions, and these functions are not part of the basis IC^4 system. Phase 2 will demonstrate the manner by which a complete IC^4 system is defined based upon a hypothetical mission model. During Phase 2, a hypothetical mission which will include selected mission unique capabilities that have been excluded from the basis IC^4 system will be defined. A total IC^4 system will then be designed illustrating deltas to the basis system necessary to accommodate the hypothetical mission case.

Phase 1 is divided into two subtasks of activity. Subtask 1 will address the functional definition of the basis IC^4 system and will depict the mission unique capabilities that are not

included in the basis system. Subtask 2 will be the detailed design of the basis IC^4 system.

Phase 2 is divided into two subtasks of activity. Subtask 1 will include detailed definition of the hypothetical mission. Subtask 2 will show the expansion of the basis IC^4 system design to encompass the hypothetical mission.